Review Of Energy Use And Sustainable Energy Opportunities In The Parish Of Ballinascreen

REVIEW OF ENERGY USE AND SUSTAINABLE ENERGY OPPORTUNITIES IN THE PARISH OF BALLINASCREEN

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Prepared by: ________________

Julie-Anne Hanna QUESTOR

John Harrison SWC

Reviewed by: ________________

Sam McCloskey CASE

Gary Sims Fathom Energy & Environment

Approved by: ________________

Dr. Wilson McGarel

QUESTOR/ CASE Director

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1.Executive Summary

The objective of the study is to develop a Renewable Energy Roadmap for the Ballinascreen Parish with a strategy to become energy neutral by 2020 through increased uptake of renewable energy in parallel with an energy programme. Although the study is primarily about community-scale projects i.e. those servicing more than one user with renewable energy, the study provides an outline of the overall renewable energy and energy efficiency strategy to achieve the energy neutrality target.

The latest European Commission Renewable Energy Directive has set the United Kingdom a challenging 15% target for the amount of total energy (across electricity, heat and transport) that should come from renewable sources by 2020. (Strategic Energy Framework 2010)

Whilst improvements to the energy efficiency of homes help to reduce the risk of fuel poverty, it is important to acknowledge that low income and high fuel prices are the main contributors to fuel poverty. Northern Ireland has a much higher dependence on oil for domestic heating (with 70% of homes using heating oil) than the rest of the UK.

This study investigated the renewable energy resources available in the study area and estimates their technical potential (primary energy resource available without considering non-technical constraints). Data compiled by QUESTOR Centre was used to examine the current energy demand in the study area; broadly grouped under key types of energy usage: heating, electricity and transport.

The current domestic energy demand for the Ballinascreen parish was estimated at 81.4Gwh per annum. The total domestic annual energy expenditure was estimated at £9,769,000 with the vast majority being spent outside the community. The industrial partners spent an additional £1,571,740 on energy within the year. The spend industrially and domestically was quite different, with the major of the industrial spend coming from transport fuels whereas the domestic spend was predominantly on oil.

A robust sustainable energy strategy needs to focus on early action in energy efficiency to reduce overall energy consumption and associated costs. Only once the energy efficiency programme is complete, should the renewable energy options for the region be fully implemented.

Recommendations are as follows:

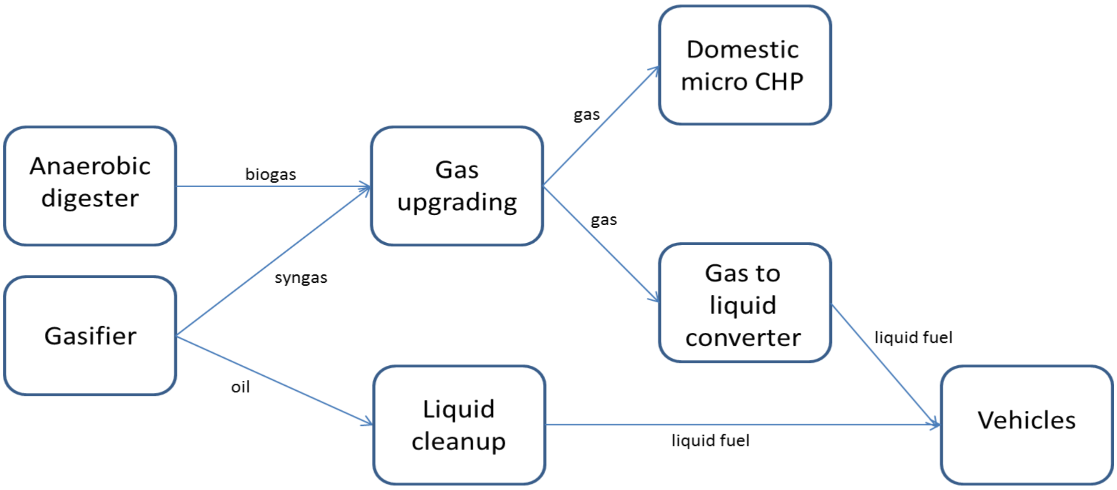
- Reducing energy demand is by far the most cost-effective measure to address energy expenditure and should be taken as a priority to lay stable foundations for the implementation of the renewable energy roadmap.

Wind energy should be exploited where possible and should be combined with the following renewable options that are recommended for further consideration:

- Option 1 is based on a system that would utilise two 500kW farm based anaerobic digestors feeding two 4GW district heating systems or one 8GW system.
- Option 2 is based on a system which would utilise four 800kW biomass boilers which would feed one 4GW district heating system.
- Option 3 is based on a system which would utilise one 1MW wood chip pyrolsis CHP which would feed a 4GW district heating system.
- Option 4 is based on a system which would utilise one 500kW farm based anaerobic digestor connected to a district gas distribution system which would feed 40 individual domestic micro CHP units and 24 larger CHP systems in community sites and SMEs.
- Option 5 is based on a system which would utilise one 1MW wood chip CHP, assuming 50% of the gas produced is used for the gas distribution system and the remainder is used for electricity production, which would be

connected to a district gas distribution system which would feed 40 individual domestic micro CHP units and 24 larger CHP systems in community sites and SMEs.

The preferred renewable energy option for the Ballinascreen Parish is a mixture of Anaerobic Digestion and Biomass Pyrolysis / Gasification feeding a District Heating System. Added value will be provided by biogas or liquid upgrade and is illustrated below. It should be noted that further development of gasification and pyrolysis is underway and should lead to more efficient processes. The investment required for this option is £12.6M with a potential payback period of 3 years.



To enable the implementation of a renewable energy plan, it is recommended that the possibility of obtaining funding to establish the Ballinascreen Parish/Draperstown area as a Sustainable Rural Community (Smart Rural) should be explored. The QUESTOR Centre and the Centre for Advanced Sustainable Energy (CASE) would assist with this objective.

Total current energy usage	81.4Gw
Planned wind turbines	0.39Gw
Existing wind turbines	0Gw
This proposed investment	8Gw
Behavior modification	8Gw
Predicted energy requirement	65.1Gw

2. Introduction

This study was commissioned by a consortium of industrial partners led by the Workspace Group in Draperstown and was funded by the Invest Northern Ireland Innovation Voucher Scheme. Nine companies have collaborated on this project and have pooled their vouchers in order to maximise the benefits from the outputs of this report. The individual energy requirements of each of the companies has been considered briefly during this study however, the main focus of the research is on the potential energy mix, including energy efficiency measures and renewable energy options for the region.

2.1 Participating Partners

The industrial consortium was made up of the following companies:

Corramore Construction - Corramore was established in 1999, and is involved in a large variety of contracts including warehousing, office developments and refurbishment of listed building, factories, hotels and residential housing.

Environment 2000 (now trading as Elite Energy) – Environment 2000 provides practical energy-saving lighting solutions to their customers. They operate throughout the UK & Ireland with a unique service of supply and installation.

Homeseal Energy Savings - Homeseal was established in 1995 and carry out residential insulation work across all of Northern Ireland and is also a registered installer on the Home Energy Saving Scheme in the Republic of Ireland. Homeseal is now recognised as the leading insulation installer in Northern Ireland.

Imed Healthcare - Established in 2007, iMed Healthcare Ltd is a pharmaceutical wholesaler who specialises in supplying the Irish retail pharmacists with a range of branded medicines, generics, test strips, needles and OTC products.

Network Personnel - Network Personnel was established in 1989 to address the skills and employment needs of those living in the Magherafelt area. A wholly owned subsidiary of the Workspace Group of Companies, it has successfully delivered a broad spectrum of DEL funded schemes.

Pharmacy Supplies - Pharmacy Supplies distributes and wholesales key performing pharmacy related products to over 1,500 pharmacies across the UK and Ireland. They source international brands from specialist global suppliers and service the retail sector in the UK and Ireland. Pharmacy Supplies specialises in wholesaling prestige fragrance, skin care, hair care, cosmetics and OTC.

Sperrin Galvanisers - Sperrin Galvanisers specialise in providing a high quality Hot Dip Galvanising service in terms of both quality and turnaround. They have two plants, one in Draperstown and the other in Tynagh, County Galway.

Workspace Enterprises - Workspace is one of 31 Local Enterprise Agencies in Northern Ireland. As a social enterprise, Workspace's core aim is to benefit the local community by providing a range of services to individuals who are considering starting their own business and to businesses looking to grow and develop.

Yardmaster - Founded in 1984 Yardmaster International has grown to become the UK market leader in the metal garden shed manufacturing sector and has established a significant presence in many other European markets supplying major retail chains. Yardmaster buildings have been used in caravan parks and private residences with gardens or swimming pools. Yardmaster has previously been awarded the Queen's Award for Export Achievement.

2.2 Existing Renewable Energy proposals in the Parish

A number of renewable energy projects are currently under proposal within the parish boundaries. These projects include Crockandun Wind Farm, a number of single turbines, three wind turbines at Creagh Concrete and two farm scale Anaerobic Digestors. Planning permission for the 18MW (6 turbine) wind farm at

Crockandun has recently been granted. This wind farm will be located between the Crockandun Hills and Straw Mountain just outside Draperstown. The Creagh Concrete 6MW (3 turbine) development, also with planning permission, is to be located at the Draperstown pit on the Lough Fea Road and Quinns wind farm.

The area under investigation in this feasibility study report, the Ballinascreen Parish, is illustrated in Figure 1.

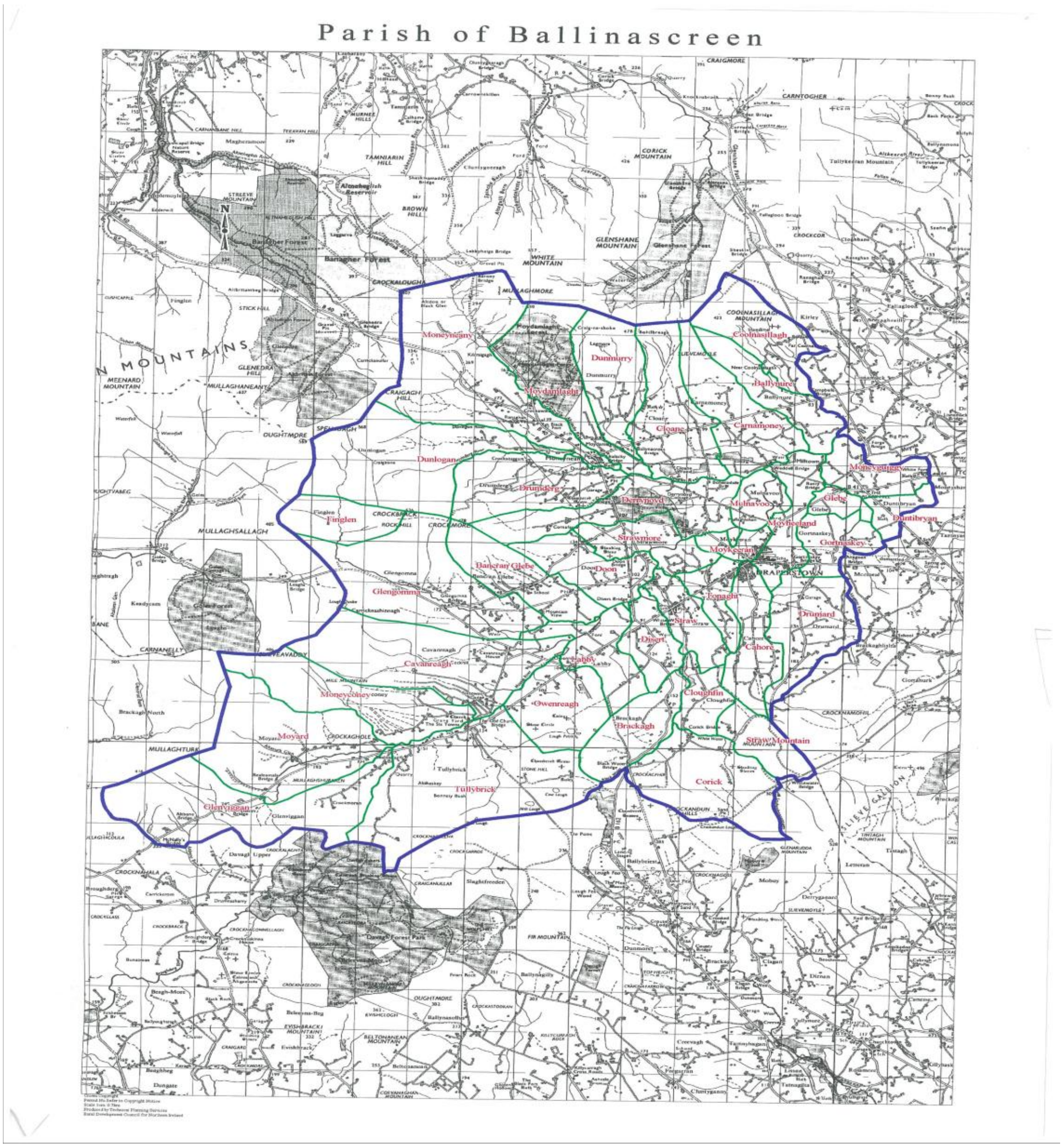


Figure 1 Map of Ballinascreen Parish

Using information collected, the following profile of Ballinscreen Parish emerges: population of 6,831 as of 2011 homed in 2,314 properties. The Ballinascreen Parish falls in the DOENI regions Upper Moyola Valley. The area is mostly rural with 97% of farms falling within Less Favoured Areas. Only 0.5% of the land is used for crops with the majority used for grass and animal grazing. There are some 3,150 cattle,20,147 sheep and the average farm size is 25hectare.

3. Upper Moyola Valley Landscape

3.1 Key Landscape Characteristics

- Broad, undulating limestone valley, dissected by numerous small, branching streams.
- Small-scale patchwork of pastures and broadleaf woodland on the valley floor; farmland on upper slopes has a relatively open character.
- Small, angular fields with dense hedgerows and numerous hedgerow trees; stone walls on more elevated slopes.
- Sharp transition between farmland patchwork and open moorland on the upland slopes to the west of the valley.
- Straight roads along margins of valley; elsewhere lanes are narrow and twisting, with fords and small stone bridges at stream crossings;
- Numerous farms and scattered cottages; a few larger settlements at principal road junctions.

3.2 Landscape Description

The Upper Moyola Valley is the broad basin of the Moyola River on the eastern fringes of the Sperrin Mountains. It is dominated by the peak of Slieve Gallion to the south. The valley is deeply undulating, with steep, rounded slopes dissected by numerous small branching streams. The slopes become steeper and smaller in scale towards the centre of the valley. The surrounding mountains provide a strong sense of enclosure. The steep slopes towards the valley centre have a relatively small-scale landscape pattern, with small pastures and many small broadleaf woodlands forming an irregular patchwork. There are numerous hedgerow trees and small copses, which often create an impression of dense woodland when viewed from the outer margins of the area.

The river is almost hidden from view. The dense tree cover creates an enclosed landscape and tends to mask the variations in landform. Many fields are partially enclosed by earthbanks and wire fences as well as by hedgerows. There is a rich diversity of trees; oak, ash, beech, birch and rowan are all found within the hedgerows and there are beech avenues leading to some of the more prosperous farms. Broadleaf woodland predominates, but there are also some small conifer plantations such as Derrynoyd Wood. The landscape becomes larger in scale towards the outer margins of the valley, where many of the fields are enclosed by stone walls. This regular field patchwork extends high up onto the slopes of the surrounding mountains, often with a striking division between the farmland and the moorland above.

There are numerous scattered white washed farms and cottages, with small clusters of buildings at some bridges and fords. Settlements are generally larger on higher land towards the outer margins of the vale. The lanes within the steeper river valleys are winding and very narrow, with abrupt turns to cross the streams on stone bridges. By contrast, on the higher land the roads are relatively straight, with long views across the vale and to the Sperrins.

3.3 Landscape Uses

The landscape is more intensively farmed on the more elevated parts of the vale, where hedgerows are in relatively good condition. However, the farmland on the lower slopes of the upland moors is of poorer quality, with gappy hedgerows, dominated by gorse and bracken. Some fields in the centre of the vale are also infested by thistles and rushes.

3.4 Key Characteristics of the Study Area

- the Upper Moyola and the Douglas River join in the centre of the Landscape Character Area (LCA) to flow through an undulating lowland
- this lowland is bordered on the north, west and south by steep slopes which are cut by incised streams
- woodlands are a major contribution to the biodiversity; many, particularly in the southwest and northwest, are located along the steep, incised streams
- pasture dominates the centre changing to poor quality pasture and semi-natural grassland on the steep boundary slopes

3.4.1 Woodlands

Woodland is a major component of the biodiversity of this LCA; it occupies around 4% of the area. The majority is broadleaf woodland and most is semi-natural. Many of the woodlands are composed of mixed broadleaves, but the species composition of others is varied depending on site conditions. Upland mixed ashwoods are common, for example along sections of the Moyola, along the White Water and several other incised streams of the steep slopes on the northern, western and southern borders of the LCA ash may be dominant, but oak, hazel and birch are often inter-mixed. Additionally, there are small stands within the woods where hazel may be dominant or where willow and alder dominate; this variation depending on the management history and on wetness of the soil. The density and richness of the understorey and herb layer depend also on the site conditions, including the intensity of grazing. Hazel and holly are common constituents of the understorey. Bluebell and other spring flowering plants may dominate the herb layer where grazing is light, whereas heavily grazed areas may have grasses or very little plant cover.

Oak is a common constituent of many woodlands in the LCA such as along the Moyola and Altagoan Rivers, but there are sites where it is dominant and forms Upland oakwood patches within woodlands. For example at Glenviggan, on steeper slopes at Nutgrove and the northern part of Coolnasilagh woodland is dominated by oak and ash. The understorey is commonly of hazel. Many of the stream-side woodlands are of old hazel, as at the Altmore Burn, at Carnamoney, and Coolnasilagh. Ash and birch often emerge through the hazel canopy although at Drumderg the taller trees are oak. Many of the hazel woodlands give the appearance of coppice, but there has been no research into their management history.
Wet woodlands of alder and willow also occur as frequent patches within woodlands; more substantial areas occur at Labby and at Nutgrove.

Modern plantation woodlands are most evident at Derrynoyd Wood; this is mainly of oak with a few beech, although there are some conifer plantings. In the south west and northwest, a few small conifer plantations, generally of Sitka spruce, are located on the steep hillsides.

The total area of woodlands in the LCA is not large, but they are frequent, of varied composition, and include several of the Northern Ireland Priority Habitats. It is essential for the landscape character of the LCA and for its biodiversity that woodlands should be retained. The woodlands have excellent assemblages of mosses, lichens and ferns growing on both living and fallen trees.

3.4.2 Grassland and Arable

Pastures occupy about 70% of the LCA and arable almost 5%. Even in the undulating central lowland, pastures are of variable quality with the poorer pastures in damper, flatter areas, often being recolonised by rushes. The better pastures are found on the slightly raised parts, although almost all pastures occupy soils of poor drainage. Field drainage and reseeding are common, so that the biodiversity is poor. There is also a transition from good pastures, through poorer pastures, to acid grassland on the boundary slopes of the LCA, especially in the south. Arable land is largely confined to better drained soils south and southeast of Draperstown and west of Tobermore.

Fields are generally small and bounded by hedgerows with a rich diversity of trees, including oak, ash, birch and rowan; shrubs include hawthorn, holly and whin. They also have many spring flowering plants at their base. Hedgerows are generally overgrown and many have become gappy.

3.4.3 Heaths and Bogs

There is very little peat bog in this LCA. There are no raised bogs and blanket peat is confined to the extreme southwest and northwest where the LCA border clips the upper slopes. The peat is thin and indeed is intermixed with humic gleys; all the peat has been cut over in the past, but there is also present cutting both by hand and compact harvester.

3.4.4 Wetlands and Lakes

There are no large loughs in the LCA. The Moyola River is a crowfoot river, a Northern Ireland Priority Habitat. The otter is recorded along many of the streams, many of which are salmonid. Timber extraction can lead to particulate pollution and acidification of rivers, but most of the rivers flowing through or alongside forests in and around this LCA do not drain into the Moyola catchment (the Altalacky river is an exception).

4. Northern Ireland Energy Targets

The Department of Enterprise, Trade and Investment's (DETI) strategic aim is for a more secure and sustainable energy system where:

- Energy is as competitively priced as possible alongside robust security of supply;
- Much more of our energy is from renewable sources and the resulting economic opportunities are fully exploited; and
- Energy efficiency is maximised.

This new Framework, which flags the direction for Northern Ireland energy policy over the next ten years, concentrates on the key areas of electricity, natural gas and renewable energy sources. It is set against what is undoubtedly a very harsh economic and financial climate with severe constraints on the public finances. It is also one where local businesses face higher costs than their counterparts in Great Britain and the region as a whole experiences the highest levels of fuel poverty in the United Kingdom. (http://www.detini.gov.uk)

In keeping with United Kingdom and wider European Union policy, the Framework recognises that the focus of energy policy worldwide has shifted towards addressing concerns about security of energy supply and tackling the threats posed by climate change. It also recognises the significant changes that have taken place since DETI published its first Strategic Energy Framework document in June 2004.

In setting out Northern Ireland's strategic energy goals it is important to consider the European Union vision of a single European energy market alongside its overarching objective of seeking to decarbonise the European Union energy mix. The targets the European Union have set for Member States are challenging and include a minimum cut of 20% in greenhouse gases by 2020, with the United Kingdom setting itself the aim of achieving an 80% cut from 1990 levels by 2050. Specifically, the latest European Commission Renewable Energy Directive has set the United Kingdom a challenging 15% target for the amount of total energy (across electricity, heat and transport) that should come from renewable sources by 2020. (Strategic Energy

Framework 2010). The Northern Ireland government has set targets in excess of the EU mandatory requirement with 40% of all electricity consumed by 2020 to come from a renewable resource and 25% of that to come from non-wind and a 10% contribution from renewable heat.

4.1 What is Fuel Poverty?

First and foremost fuel poverty is a subset of poverty and must be viewed in the context of overall poverty. A fuel poor household is defined as one which needs to spend more than 10% of its income on all fuel use and to heat its home to an adequate standard of warmth.(Energy UK)

The Northern Ireland House Condition Survey 2009 shows that 44% of households in Northern Ireland have to spend more that 10% of their income on energy costs. The World Health Organisation defines a satisfactory heating regime as 21^{o}C in the living room and 18^{o}C in other areas, although householders with specific needs may require different levels of heating. The number of people living in fuel poverty in Northern Ireland far exceeds the numbers in the other regions of UK; however, an upward trend is evident in all regions.

Region	Level of Fuel Poverty
Northern Ireland 2009	44%
Scotland 2009	33%
England 2008	16%
Wales 2008	20%

Table 1Fuel Poverty throughout UK

The differences in average annual fuel bills across the regions of Northern Ireland and Britain and the percentage of disposable household income this represents are considerable. Households in Northern Ireland spend more than twice as much of their disposable income on energy than households in London and around 60% more than the UK average. The difference is explained by a number of factors, each of which impact on one of the three primary factors contributing to fuel poverty:

- heat needs are greater because of our latitude and climate and because of the higher proportion of rural households (not sheltered within towns);
- household incomes are lower and we have higher rates of benefit dependency; in 2010 average earnings were £356 per week compared to £404 in the UK;
- the unemployment rate in Northern Ireland has risen from 4.1% in August to October 2005 to 7.8% in April 2013, higher than the UK rate (7.7%), the European Union rate (12.1%) and the Republic of Ireland rate (14.1%);
- Northern Ireland has a much higher dependence on oil for domestic heating with 70% of homes using oil to heat their homes;
- energy costs are higher due mainly to our exposure to the transportation costs associated with our reliance on fossil fuels and our much smaller energy market.

Within Northern Ireland there are geographical variations in the levels of fuel poverty. As demonstrated in Table 2, in 2011 the Magherafelt council area had the highest number of households in fuel poverty, in terms of the proportion of local households in fuel poverty within a local population, followed by Strabane and Ballymoney both with 46.0%. The Magherafelt Council area includes the study area.

Council Area	%. of Households in fuel poverty
Antrim	41
Ards	28
Armagh	29
Ballymena	40
Ballymoney	46
Banbridge	31
Belfast	39
Carrickfergus	23
Castlereagh	21
Coleraine	29
Cookstown	35
Craigavon	45
Derry	37
Down	27
Dungannon	23
Fermanagh	34
Larne	36
Limavady	41
Lisburn	27
Magherafelt	47
Moyle	38
Newry & Mourne	23
Newtownabbey	33
North Down	25
Omagh	34
Strabane	46

Table 2 Fuel Poverty by district council area 2011

5. Programme of Work

This study involved a programme of work that was broken down into a number of tasks as follows:

Task 1: An analysis of the current energy demand in the study area. Presented in Section 6.

Task 2: An investigation of the preferred renewable energy options available in the study area and an estimate of their technical potential (primary energy resource available without considering non-technical constraints). The options were based on those technologies that are deemed to be sufficiently developed to enable utilisation by 2020, including a SWOT Analysis in each case. Presented in Section 7.

Task 3: Recommendations for longer term renewable energy options where the technologies were not considered to be ready for utilisation by 2020 and also including technologies which are more suited to single users. Presented in Section 8.

Task 4: Calculation of capital costs on recommended options. Presented in Section 9

Task 5: Conclusion and Recommendations. Presented in Section 10

6. Energy Demand

Data compiled by QUESTOR Centre was used to examine the current energy demand in the study area; broadly grouped under key types of energy usage: heating, electricity and transport. An understanding of the energy demand in the area is key to understanding how energy is used, how much it can be reduced and in quantifying the amount of renewable energy that can be produced to achieve energy neutrality.

6.1 Current Energy Demand - domestic

The current energy demand has been assessed on the basis of the energy survey carried out by QUESTOR among households within the parish. The data was collected with the help of the local secondary school; a questionnaire (which is available in Appendix 1) was circulated in the school with 74 completed forms returned. A medium analysis was applied to the collected data to remove any outliers which indicate errors. The original data is available in Appendix 2 and a summary in Table 3.

		Electricity	Gas	Oil	Solid Fuel	Vehicle Fuel
Draperstown	**Total cost**	£72,580	£2,145	£46,660	£17,290	£93,232
Maghera	**Total cost**	£5,045	£260	£2,760	£1,632	£5,880
Cranagh	**Total cost**	£1,780	£100	£1,880	£350	£7,400
Moneymore	**Total cost**	£9,522	£688	£12,069	£3,002	£31,760
Desertmartin	**Total cost**	£9,320	£25	£1,980	£1,438	£12,810
Tobermore	**Total cost**	£850	£72	£870	£520	£1,560
Total	**Total cost**	£99,096	£3,290	£66,219	£24,232	£152,642
	Unit cost	0.1531	0.3115	0.626	0.22	1.46
	Unit/ kWh	1	7.15	12	7.5	
	Total units	647268.84	10562.76	105782.11	110145.45	104549.32
	Total kWh	647268.84	75523.74	1269385.30	826090.91	
	kWh/house	8746.88	1020.59	17153.86	11163.39	
	kWh use in all homes	20,240,272	2,361,648	39,694,022	25,832,086	
	All homes	**Total kWh**	88,128,027			

Table 3 Summary of the collected data

		Electricity	Gas	Oil	Solid Fuel	Vehicle Fuel
Draperstown	**Total cost**	£39,499	£2,145	£46,660	£17,290	£93,232
Maghera	**Total cost**	£5,045	£260	£2,760	£1,632	£5,880
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Total	**Total cost**	£66,016	£3,290	£66,219	£24,232	£152,642
	Unit cost	0.1531	0.3115	0.626	0.22	1.46
	Unit/ kWh	1	7.15	12	7.5	
	Total units	431200.91	10562.76	105782.11	110145.45	104549.32
	Total kWh	431200.91	75523.74	1269385.30	826090.91	
	kWh/house	5827.04	1020.59	17153.86	11163.39	
	kWh use in all homes	13,483,769	2,361,648	39,694,022	25,832,086	
	All homes	**Total kWh**	81,371,524			

Table 4 Summary of the medium analysed data

The average energy for household usage was calculated using the following values

Electricity – 3,500 kWh pa provided by Airtricity

Gas – 12,232 kWh for 2011 and 11,957 kWh for 2012 – difference related to a slightly milder year (source Airtricity Gas NI) – NOTE these are natural gas figures and will include natural gas as main heating source not just for cooking/top-up

Coal – 1,500 kg pa based on 50kg per week for 30 weeks of the year (11,250 kWh) (source LCC)

Oil – was 2,700 litres pa (32,400 kWh) but in past 2 years has been 1,500 litres pa (18,000 kWh) (source LCC). If 'poor' households then 150 litres every 2 weeks using small tanks or minimum delivery

The study area average energy use was calculated using Northern Ireland regional energy use figures. As there is limited gas use in the study area, it has been excluded from the calculated figures in Table 5.

	Average kWh	**No. of homes**	**Total kW**
Electricity	3500	2314	8,099,000
Oil	18000	2314	41,652,000
Solid fuel	11250	2314	26,032,500
		Total	75,783,500

Table 5 Extrapolated energy consumption for study area using regional average consumption data

The total domestic energy demand is estimated at 81.4GWh per annum for the whole area and for all types of energy usage, which is higher than the regional average calculated from data provided by Airtricity and LCC. Figure 2 illustrates the distribution of energy usage between energy types.

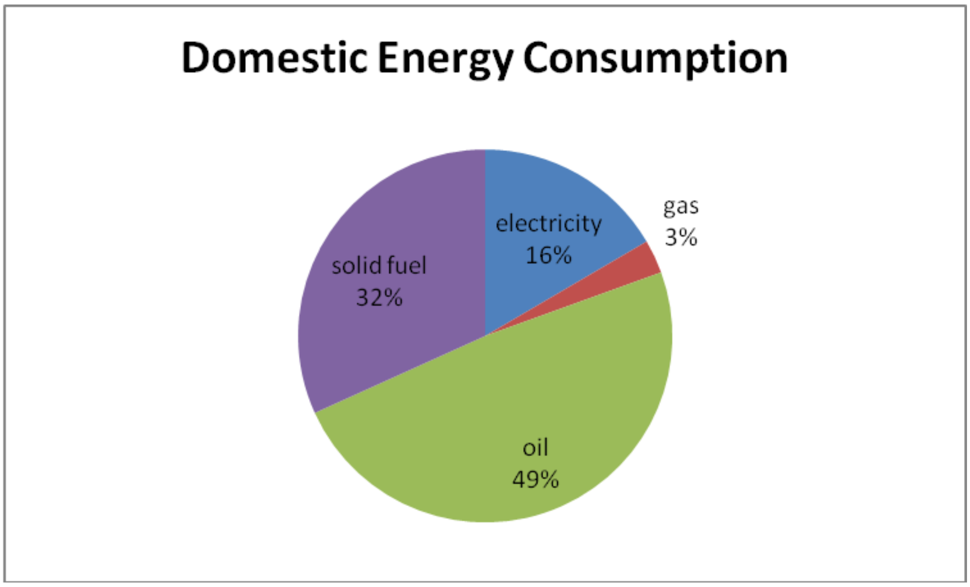

Figure 2 Distribution of energy usage between energy types

6.2 Current Energy Demand – Industrial

The current energy demand has been assessed on the basis of the energy survey carried out by QUESTOR among selected companies within the parish. Data was obtained through questionnaire survey with each of the nine companies in the Innovation Voucher project. A copy of the questionnaire is available in Appendix 1. The original data is illustrated in Table 6 Industrial sites annual energy spend

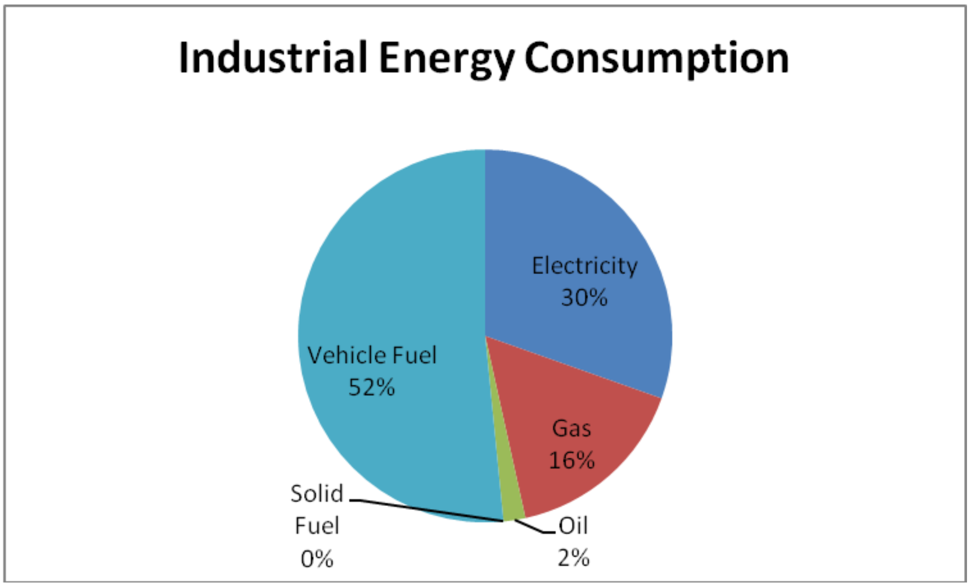

Figure 3 Distribution of energy usage between energy types

			£/yr	£/yr	£/yr	£/yr	£/yr
Company Name	Sector	Turnover	Electricity	Gas	Oil	Solid Fuel	Vehicle Fuel
Environment 2000	Lighting	£500k -1M					£20,051
Heron Bros	Construction	£5M+	£162,278		£6,538		£610,200
Yardmaster	Flat pack metal sheds	£5M+	£45,000				
Corramore Construction	Construction	£5M+	£3,000		£1,000		£85,000
Sperrin Galvanisers	Galvanising	£5M+	£37,350	£153,464			
Workspace Enterprises	Training	<£500K	£6,732		£2,259		
Homeseal Energy Savings	construction	£1M -3M	£3,187				£139,276
Networks Personnel	training	£3M -5M	£9,806				£3,119
Pharmacy Supplies	wholesale	£5M+	£8,133		£5,061		£42,095
Sperrin Metals	construction	£5M+	£154,551	£31,504	£10,114		£6,920
Totals			**£430,037**	**£184,968**	**£24,972**	**£0**	**£906,660**

Table 6 Industrial sites annual energy spend

7. The Investigated Renewable Energy Options

The renewable energy potential within the area was assessed and the results are presented herein. An assessment has been made of all of the renewable energy resources with a practical potential to contribute to the objective of energy neutrality in the region. While renewable energy covers a wide range of natural resources, the focus was on those for which energy technologies are readily available or are considered sufficiently developed to start making a contribution by 2020.

7.1 District heating

District heating is a system for distributing heat generated in a centralised location for residential and commercial heating requirements such as space heating and water heating. Systems use a centralised heat source and a network of pipes to provide heat for a number of buildings. District heating is common in mainland Europe. Recently a number of areas in Britain have successfully installed systems, or have plans to do so, and in Dublin plans are moving ahead to distribute heat from the Poolbeg Incinerator.

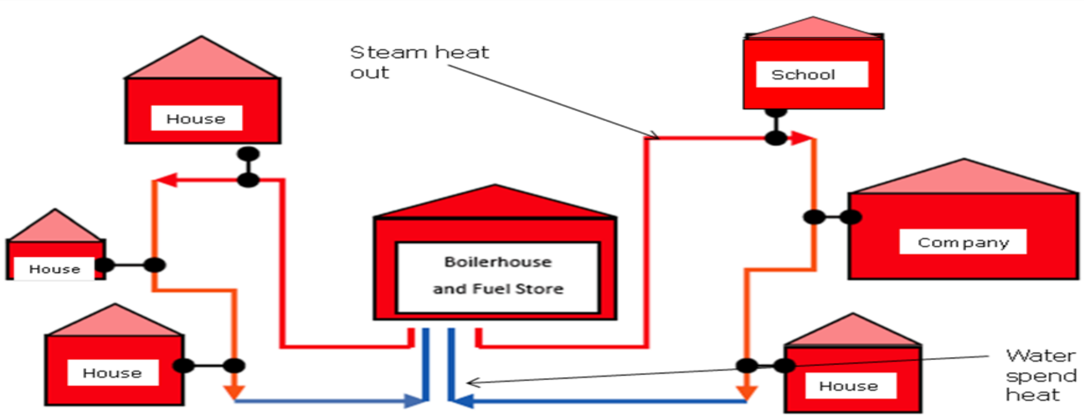

Figure 4 District heating

The common medium used for heat distribution is water, but steam is also used. The advantage of steam is that in addition to heating purposes it can be used in industrial processes due to its higher temperature. The disadvantage of steam is a higher heat loss due to the high temperature. Also, the thermal efficiency of cogeneration plants is significantly lower if the cooling medium is high temperature steam, causing smaller electric power generation. Heat transfer oils are generally not used for district heating, although they have higher heat capacities than water, as they are expensive, and have environmental issues.
At customer level the heat network is usually connected to the central heating of the dwellings by heat exchangers. The water (or the steam) used in the district heating system is not mixed with the water of the central heating system of the dwelling. Typical annual loss of thermal energy through distribution is around 10%, as seen in Norway's district heating network.

7.1.1 A Working Example of a District Heating System

Shetland Heat Energy and Power Ltd has been providing district heating to both domestic and non-domestic properties in Lerwick since 1998. Hot water is pumped around Lerwick through underground insulated pipes and enters properties through a heat exchanger, supplying their heating and hot water needs. The heat used in the scheme is generated at a Waste to Energy Incinerator located on the outskirts of Lerwick. The incinerator at the Energy Recovery Plant burns domestic and commercial waste from Shetland, Orkney and from the offshore oil industry, reducing the amount of waste going to landfill. By June 2009 there were a total of 1002 connections and 961 of these are receiving heat.

As the number of Shetland District Heating System customers is increasing, an additional energy source is essential. In 2006 a hot water storage tank was installed to store excess heat during off-peak periods and provide heat during peak loads. This allowed for the equivalent of a further 500 properties to be connected without the need for an additional heat source. Another 6.5 MW boiler was installed in 2008 to give a total back up capacity of 15 MW based at the Peak Load Boiler Station. Using customer's former boilers as additional back-ups, there is a further 6 MW of boiler capacity spread around Lerwick. During 2007/08 a radio transmitting system was installed to collect customer meter readings and transmit them directly to the Shetland District Heating System office on demand.

Figure 5 Shetland District Heating System

One of the biggest surprises that the Shetland District Heating System found when connecting large customers was how small a peak demand they required compared with the oil fired facilities that were previously provided.. Even though oversized heat exchangers have often been installed, based on the original provision, these are a mere fraction in costs and space compared with oil boilers. From an economic view point the district heating scheme contributes a significant role in the Shetland economy:-

- About £1,000,000 per annum of the income from sales stays in Shetland rather than paying for oil which would go straight out of the economy. In addition the customers are saving between £300,000 and £1,000,000 depending on the price of oil.
- An important part in reducing fuel poverty is being realised at a time when, in the UK, more are falling into it as a result of rising prices. Just as importantly, local businesses are cushioned from the fuel price uncertainty helping to provide some stability. For services such as local government and the Health Board this is equally important where budgets are under pressure.
- New large buildings such as the museum and high school will have massive capital savings on plant facilities. The area required for a heat exchanger can be less than 20% than that for boilers and there is no need for storage tanks and flue.
- Large users are also finding they have significant reductions in maintenance over conventional boilers. Also, administration is no longer required for ordering and monitoring fuel.
- Up until recently approximately £700,000 of civil engineering works a year were created of which around 75% was local input with the remainder being materials.
- Housing being converted to wet radiator systems are generating over £300,000 of plumbing works of which much of the cost will be local labour input.
- The district heating scheme directly employs six people. It out sources most of its maintenance works to the private sector.

The Energy Recovery Plant also plays an important economic role in addition to its environmental benefits:

- Creating about twenty direct jobs
- Reducing landfill tax which is rising significantly each year

7.2 Heat Generation

The core element of a district heating system is as a minimum a heat-only boiler station. Additionally a cogeneration plant (also called combined heat and power, CHP) is often added in parallel with the boilers. Both are typically based on combustion of primary energy carriers. The difference between the two systems is that, in a cogeneration plant, heat and electricity are generated simultaneously, whereas in heat-only boiler stations - as the name suggests - only heat is generated.

Conventional fuels such as gas and oil can be used to operate district heating systems but, increasingly, systems make beneficial use of waste materials and biomass. Biomass heating is environmentally-friendly and sustainable and is scalable with installations of a few hundred kilowatts proving to be economically viable for the delivery of renewable energy.

The options for heat generation considered as part of this study were

- Biomass combustion
- Combined heat and Power
- Anaerobic digestion.

7.3 Biomass Combustion

Biomass is fuel derived from living or recently living material, such as wood, energy crops and certain plant oils. Combustion of biomass fuel to produce heat releases carbon dioxide to atmosphere but these emissions are offset by the carbon dioxide originally absorbed during the growth of the biomass. Biomass is not entirely carbon neutral, however, as further greenhouse gas emissions can be associated with the harvesting, transport and processing of the fuel.

With all of these considerations correctly taken into account, combustion of carefully chosen biomass fuels has the potential to make significant savings in carbon emissions, when compared to combustion of fossil fuels.

So called “second generation” biomass fuels are often liquids or gases, derived from processing biomass feedstocks in some way, such as anaerobic digestion or pyrolysis. These processes can often use organic waste as a feedstock and therefore do not necessarily result in the same impact on land use change or competition with food production as some first generation biomass fuels.

7.3.1 Potential Feedstocks

7.3.1.1 Miscanthus

Miscanthus is a high-yielding perennial, rhizomatous grass with lignified stems resembling bamboo. Once established (typically requires 2-3 years) miscanthus can remain in situ for at least fifteen years. Miscanthus is planted in spring and harvested over the winter and early spring months. In excess of 2,000 ha have been planted across Ireland since 2007.

M. sinensis *M. sacchariflorus* *M. giganteus*

Figure 6 Three main species of *Miscanthus (afbi)*

The crop is growing throughout the country on a wide range of soils, from sands to high organic matter soils. Harvestable yields vary on average between 12 and 16t/ha year which can be used as a feed stock for combustion/gasification. Miscanthus has been reported growing, and producing high or reasonable yields on a range of soils, from sands to high organic matter soils. It is also tolerant of a wide range of pH, but the optimum is between pH 5.5 and 7.5, so suitable to grow in the study area. The potential farm gate price for 1 tonne of miscanthus with a moisture content of approximately 20% is £51.00, whereas wheat has a gate price of £109 per tonne..

7.3.1.2 Short Rotation Coppice (willow and/or poplar)

Short Rotation Coppice (SRC) (willow) is a fast growing species that can be grown to produce woodchip for heat and power generation over a 3- to 4-year cycle for up to 20-25 years. First year growth is normally cut-back to encourage the multiplication of shoots, and then full harvest typically takes place every 3 to 4 years. Harvesting is carried out from November to the end of February, when foliage is absent and stem moisture content is at its lowest (approximately 55%). The crop is capable of yielding 10 to 12 oven-dry tonnes of biomass per hectare per annum on good sites, but it is expected that new clones will yield 12-14 OD tonnes/ha,year. The application of wastewater or wastewater treatment sludge to a short rotation coppice stand can increase average yields by up to 30%, by increasing the availability of nutrients and water to the plantation – two growth factors to which willow responds very well. This is referred to as biofiltration or bioremediation. It has attracted a lot of attention in recent years as an effective system to treat wastewater and other effluents, which provides additional income to growers through gate fees and increase yields. The potential farm gate price for 1 tonne of willow with a moisture content of approximately 20% is £70.00, whereas wheat has a gate price of £109 per tonne.

Figure 7 Willow (afbi)

7.4 Combined Heat and Power (CHP)

CHP is the generation of on-site electricity whilst simultaneously utilising the waste heat from the process for useful purposes, such as heating water. Heat is always produced during power generation but is usually not recovered for useful purposes, giving an overall efficiency for the conversion of fuel into useful energy of just 30% - 40%. By recovering the heat produced in the process, the overall efficiency of energy conversion can be increased up to 80% - 85%.

A CHP unit typically consists of either a reciprocating engine or a turbine, running on either natural gas or diesel (or biogas/biodiesel). The combustion of the fuel within the engine creates motive power, which is converted into electricity via the alternator. Exhaust gases typically leave the engine at approximately 500°C. A heat exchanger placed in the flow of exhaust gases transfers this heat to a working fluid, typically water, which is heated to a high temperature or raised to steam. Low temperature hot water (LTHW) can also be recovered from the engine jacket cooling circuits and the aftercooler.

7.4.1 Biomass CHP

Biomass CHP utilises fuel more efficiently than combustion producing heat alone. Typically, the biomass fuel is combusted to raise steam which then drives a turbine. Heat is also recovered from the exhaust gases. Biomass CHP is typically more expensive than its gas fired counterpart, and can require a significantly larger footprint for a system with equivalent output. The same feed stocks for biomass combustion would work as feed stocks for CHP.

After generation, the heat is distributed to the customer via a network of insulated pipes. District heating systems consist of feed and return lines. Usually the pipes are installed underground but there are also systems with overground pipes. Within the system heat storages may be installed to even out peak load demands.

Systems produce steam or hot water at a central energy centre from which it is pumped through pre-insulated pipework to individual buildings. Instead of requiring individual boilers, houses and buildings are supplied from this central source with controlled-temperature water for space heating and domestic hot water. Increasingly there is interest in cogeneration of electricity along with heat and hot water in combined heat and power (CHP) installations.

Heating pipes form a network to link buildings together to distribute heat, usually as hot water, from a decentralised energy generation station. Network pipes are pre-insulated and traditionally then buried in the ground; however, as the civil costs associated with this are high, it is advantageous if above ground installation routes can be found, for example in building basements and underground car parks.

Heating networks typically fall into two categories, low temperature (a flow temperature of circa 80°C) and high temperature (a flow temperature of circa 100 to 120°), although there are temperatures in between these and each network must be designed to be compatible with the connected buildings and take into account the local topography.

If at all possible the use of a lower temperature network is recommended as this significantly reduces heat losses, increases the energy which can be used for lower temperature sustainable energy sources, and allows for lower cost piping systems to be utilised.

For lower temperature systems which operate with flow temperatures which are below 95°C it is possible to utilise plastic pre-insulated pipework which is manufactured in rolls of up to 100 metres. Although this pipework can only be used for heat loads up to a certain size, above this size, or where the use of plastic pipe is not possible, then typically 12 metre lengths of pre-insulated steel pipework are used with bonded insulation which can contain alarm wires to detect moisture.

Many district heating schemes operate at temperatures and pressures that are compatible with typical building services. In this case, consumers' heating systems can be directly connected to the district scheme, with the same water that flows in the district network flowing through consumers' heating circuits. However, sometimes it is necessary to operate district heating systems at higher temperatures than consumers require and higher pressures than consumers' systems are designed to withstand. For example, the network must operate at a flow temperature of at least that of the highest individual consumer's distribution flow temperature. Additionally, the variations in building height and ground levels, across a district-heating system, can result in a need to operate the district-heating network at higher pressures than the consumers' own heating systems.

Where the temperatures and pressures of consumers' heating systems differ from those of the district heating network, it is usually necessary to utilise a thermal substation. A thermal substation typically consists of a plate heat exchanger which acts as a pressure break between the district network and consumer system. The heat exchanger often forms part of a metering station (with flow control valves, isolation vales and a heat meter) which acts as the demarcation point between the district scheme and consumer systems.

The size of such a metering station varies depending on the size of the energy loads it is designed to meet. A district heating connection will typically offer a substantial space saving when compared to the space that would be required for conventional boiler plant to meet the equivalent heat load.

Domestic connections are typically achieved with Heat Interface Units (HIUs, sometimes referred to as "heat boards"). As with commercial connections, HIUs also contain flow controls, isolation valves and heat metering equipment. Instantaneous domestic hot water supplies are generated in a plate heat exchanger and space heating circuits can be either directly connected to the residence's systems or also connected via a plate heat exchanger.

When building a District Energy Scheme it is important to consider a metering strategy from the outset. Metering serves two purposes, the first is energy monitoring and the second is consumer billing/cost recovery. If the scheme does not involve cost recovery, because it is a totally self-developed/self-contained scheme then the decision could be made to install a system which only provides sufficient information to monitor the energy consumed but does not require "revenue grade" metering. It may be that the choice is made to only install metering for monitoring purposes, because energy costs are apportioned on a floor area or unit (dwelling) basis, however schemes being developed using this approach are becoming increasingly rarer as it gives little incentive to the end consumer if their energy bill is not linked directly to usage.

For the energy generation plant itself, it is good practice and typically a requirement under legislation, to install an energy input and output meter wherever practically possible for each piece for plant, i.e. a CHP unit or boiler. By continuous monitoring of these meters an energy balance for the plant can be obtained and deviations in efficiency compared to design levels can be quickly identified and then rectified. Typically there are two choices for linking the energy meters across a district energy network. The first is to link the meters to the Local Area Network used for the building automation system controlling the plant in the energy centre. This is normally achieved by inputting pulses from the meters into the LAN (for each tranche of kWh or MWh passing through the meter), which can then be read remotely at the energy centre. Alternatively a separate metering network (an MBuS) can be installed, particularly to retain the integrity/robustness of the metering system and return a greater amount of information from the meters (on temperatures, flow rates etc.) to the central energy centre.

District Energy networks derive significant benefit from economies of scale, drawing together multiple diverse loads to provide an energy base-load which high-efficiency, low-carbon plant can operate against. The potential for carbon and cost savings is realised by the choice of plant which supplies the energy (heat, cooling or electricity) to consumers, via the district energy networks. The networks themselves are “multi fuel”. Therefore, as new technologies become viable (such as fuel cells or the latest generation of biomass CHP) these can effectively be “plugged in” to the existing network and serve the aggregated loads of the district energy scheme. This approach is far more effective than relying on action by individual consumers, which could not provide the same level of carbon and cost effectiveness, especially in the same timescale.

A district heating system could provide heating to a number of homes and businesses in the district, depending on the source of the heat the system could be one part of a more holistic system that is also producing electricity.

7.4.2 Biomass CHP SWOT Analysis

Strengths	District heating (and energy) provides the following benefits: • Energy efficiency. Aggregating a number of diverse consumer loads can allow district energy schemes to benefit from significant economies of scale. As well as improved overall efficiency from larger scale plant, a scheme's energy base-load can be met by combined heat and power (CHP) technology, maximising the efficiency of primary fuel use. • Increased environmental performance. The improved energy efficiency and ability to use low carbon forms of energy generation mean that district energy can provide an environmentally friendly energy solution. Energy enters the site in the form of heated and chilled water, negating the need for fuel and refrigerants to be used on-site. • Fuel flexibility. District energy systems are fuel agnostic, meaning that its many customers can benefit from changes in the primary generation technology at the central energy centre. District energy systems can use a variety of fuels such as natural gas and biomass, adapting depending on whichever fuel is most competitive or appropriate at the time. • Ease of operation and maintenance. District energy supplies outsource the risk to the energy suppliers, delivering heat and cooling directly to consumer

	buildings on an output specification. Customers do not need boilers or chillers, so there is less plant to operate and maintain on site. • Reliability. District energy systems are monitored 24 hours a day, 365 days a year, and have backup systems readily available. • Comfort and convenience for consumers. Despite being generated at a central energy centre, energy supplies from the district systems are completely controllable by each individual consumer. Supplies of heat and cooling are available all year round. • Reduced costs. Because consumers of district energy services don't require boilers or chillers on site, building owners and managers face significantly reduced capital costs, operational costs and costs of plant replacement. Financial risk is diminished and the costs of parts, labour and insurance are all reduced. Energy supplies from district energy schemes are less costly than the whole life cycle costs of owning and operating energy plant on-site. • Increased functional space on-site. No boilers, chillers, gas equipment, chimneys or cooling towers on-site means substantially greater building design flexibility. This increased space on-site can result in an increased saleable area for a given plot. Benefits with District Heating and Combined Heat and Power • The fundamental idea of district heating is based on the use of recycled heat and/or the use of renewables. • These energy supplies are complemented by some traditional fossil fuels for peak and reserve capacity.

	• Heat can be recycled from electricity generation from fuels (combined heat and power), from waste incineration in Waste-to-Energy plants, and from industrial processes. • Renewables used in European district heating systems are: Bioenergy (biomass, biogas etc), geothermal heat, and solar energy through solar collectors. The use of heat recycling provides: • Higher energy efficiency, since the energy system heat losses are lower compared to the combination of alternative heat supply and alternative electricity generation • Lower primary energy supply, from the higher energy efficiency • Lower energy import, from the lower primary energy supply, giving a higher domestic share • Lower carbon dioxide emissions, since alternative primary energy supply are based on fossil fuels • The use of renewable energy supply provides: • Lower energy import, since renewables used are domestic resources • Lower carbon dioxide emissions, since fossil fuels are substituted from both heat supply and electricity generation
Weaknesses	Urgent Needs/Challenges • Currently, district heating struggles because of the high capital cost (which is thought to be higher in UK than in mature district heating countries), lack of awareness, and the poor performance of some older existing schemes. • Operating in the liberalised market hampers district

	heating; whilst competitor infrastructure established previously was installed using mostly public (lower NPV) money. This removed risk, which continues to be taken out because it is shared across the whole regulated asset base. • Yet district heating achieves well with respect to 3 government imperatives as set out in the Energy White Paper: carbon reduction, fuel poverty, and security of supply, failing only on the 4th, namely competitiveness. Hence the need for incentives for district heating.
Opportunities	• Mandatory CO_2 reductions for UK authorities including NI many of whom are redrafting their planning frameworks. Fuel poverty alleviation and the growing issue of security of supply are also important. • If properly configured, the RHI could incentivise CHP as well as renewables.
Threats	• Capital cost is a major barrier; this technology requires a long-term view, but the financial markets do not support this long-term view. The public sector can accept lower NPV and lower cost of borrowing, but local authorities are cash-starved in revenue and capital. • VAT policy on fuel and power: due to sensitivities such as fuel poverty VAT is levied at only 5% (as opposed the full rate of 20%) on gas and electricity bills. Hence energy remains relatively cheap and the payback for capital-intensive carbon-saving technologies is artificially lengthened. • Undertaken 2 decades ago, the privatisation of the electricity industry hampered the establishment of district

	energy. Current electricity trading arrangements make it difficult to sell electricity to the grid from local scale CHP. • Planning policy with respect to power stations means that developers have established them where there is no available heat load. • Lack of knowledge and awareness is also a barrier: politicians and pundits should talk much more about district energy. So electricity and gas remain the presumed energy distribution networks. • Lack of experience in the contracting sector is also a problem: only a handful of companies can install leading to lack of competition expensiveness. • Arrangements for competition in energy markets such as the 28-day rule (within which time a consumer has the right to switch supplier).

7.5 Anaerobic Digestion

Anaerobic Digestion (AD) is the breakdown, by bacteria, of organic substances in an oxygen-free environment, to produce a biogas. The biogas will be a mixture of methane (50-75%), carbon dioxide (25-45%), moisture (2-7%) and trace gases such as hydrogen sulphide, hydrogen, oxygen, nitrogen and ammonia. The organic substance must be biodegradable solids or liquids and can be sourced from industrial, municipal or farm wastes. These feedstock/wastes are fed (some require pre-treatment) into a closed vessel which has been inoculated with a suitable bacteria. Under zero oxygen anaerobic conditions prevail causing bacteria to breakdown the organics to methane or other products as described above. The digester is held at a constant temperature throughout.

As previously stated, AD is a microbiological process of decomposition of organic matter in absence of oxygen. The main products of this process are biogas and digestate. Biogas is a combustible gas, consisting primarily of methane and carbon dioxide. Digestate is the decomposed substrate, resulting from the production of biogas. During AD, very little heat is generated in contrast to aerobic decomposition (in presence of oxygen), such as during composting. The energy, which is chemically bonded in the substrate, remains mainly in the produced biogas, in the form of methane.

The process of biogas formation is a result of linked process steps, in which the initial material is continuously broken down into smaller units. Specific groups of micro-organisms are involved in each individual step. These organisms successively decompose the products of the previous steps. The simplified diagram of the AD process, shown in Figure 8, highlights the four main process steps: hydrolysis, acidogenesis, acetogenesis, and methanogenesis.

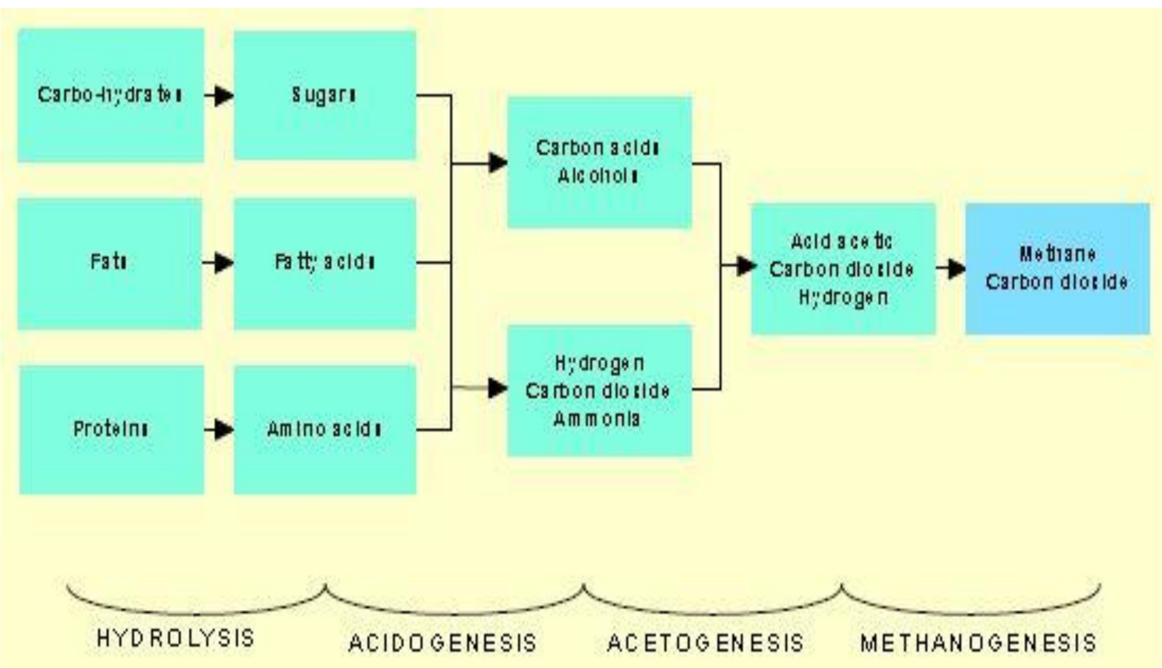

Figure 8 AD process steps

- Hydrolysis: Hydrolysis is theoretically the first step of AD, during which the complex organic matter (polymers) is decomposed into smaller units (mono- and oligomers). During hydrolysis, polymers like carbohydrates, lipids, nucleic acids and proteins are converted into glucose, glycerol, purines and pyridines. Hydrolytic microorganisms excrete hydrolytic enzymes, converting biopolymers into simpler and soluble compounds A variety of microorganisms are involved in hydrolysis, which is carried out by exoenzymes, produced by those microorganisms which decompose the undissolved particulate material. The products resulted from hydrolysis are further decomposed by the microorganisms involved and used for their own metabolic processes.

- Acidogenesis: During acidogenesis, the products of hydrolysis are converted by acidogenic (fermentative) bacteria into methanogenic substrates. Simple sugars, amino acids and fatty acids are degraded into acetate, carbon dioxide and hydrogen (70%) as well as into volatile fatty acids (VFA) and alcohols (30%).
- Acetogenesis: Products from acidogenesis, which cannot be directly converted to methane by methanogenic bacteria, are converted into methanogenic substrates during acetogenesis. VFA and alcohols are oxidised into methanogenic substrates like acetate, hydrogen and carbon dioxide. VFA, with carbon chains longer than two units and alcohols, with carbon chains longer than one unit, are oxidized into acetate and hydrogen. The production of hydrogen increases the hydrogen partial pressure. This can be regarded as a “waste product“ of acetogenesis and inhibits the metabolism of the acetogenic bacteria. During methanogenesis, hydrogen is converted into methane. Acetogenesis and methanogenesis usually run parallel, as symbiosis of two groups of organisms.
- Methanogenesis: The production of methane and carbon dioxide from intermediate products is carried out by methanogenic bacteria. 70% of the formed methane originates from acetate, while the remaining 30% is produced from conversion of hydrogen (H) and carbon dioxide (CO_2). Methanogenesis is a critical step in the entire anaerobic digestion process,

as it is the slowest biochemical reaction of the process. Methanogenesis is severely influenced by operation conditions. Composition of feedstock, feeding rate, temperature, and pH are examples of factors influencing the methanogenesis process. Digester overloading, temperature changes or large entry of oxygen can result in termination of methane production.

7.5.1 Feedstocks for Anaerobic Digestion

Industrial sources include: Slaughterhouses, food manufacture and catering waste, fats oils and greases, distillers and food packagers.

Municipal sources include: municipal solid waste (MSW), green wastes (grass and garden), brown bin type wastes.

Agricultural sources include: animal slurries and litters, grass and silage, other energy crops (grains etc.)

7.5.2 Cow Slurry

Cow slurry is typically collected from feedlots by a scraper system. Straw is often added in the feedlots resulting in slight variations of total solids. Commonly small amounts of water are used for cleaning and rinsing of the cattle walkway, hence dilution with water is minimal. Cow slurry exhibits large variations in total solids contents, depending on the animal housing system. Depending on the location and operational tradition cows often spend long periods of time grazing on pastures. Reduced overall manure collection must therefore be considered in economic evaluations.

7.5.3 Farmyard Manure

Animals are typically kept on straw, which absorbs the excrements resulting in dry matter contents ranging from 10 to 30 % TS. The digestion of farmyard manure requires considerably higher retention times and often demands a pre-treatment of the inhomogeneous manure. Frequently, additional operational problems like scum layer formation, are observed. Some bedding materials such as wood shavings are (due to their high lignin content) difficult to degrade anaerobically and may need to be enriched in the digestion tank.

7.5.4 Harvest Residues and Garden Wastes

Harvest residues and garden wastes, remaining on or recycled to agricultural land may also be used as feedstocks in farm digesters provided the effluent can be applied conveniently to agricultural farm land. Commonly such residues will be added as co-substrates to manure. Possible feedstocks for anaerobic digestion include plants and plant remains (e.g. leafs, corn, clover, stems etc.), spoiled or low quality fruits and vegetables, silo leachate and straw.

7.5.5 Energy Crops for AD

Efforts have been made to cultivate crops specifically for anaerobic digestion (biogas collection) purposes. This could be of interest for countries where energy costs are high, while sufficient agricultural land in mediate climate is available. Even in Europe, where agricultural over production occurs, anaerobic digestion of energy crops might be a possible alternative to using fallow areas. However currently energy crops for anaerobic digestion have not reached any significance in the EU, (Nordberg, 1997).

All of these feed types have the potential to produce biogas to varying degrees depending on their chemical and physical properties. Blending feedstocks together, or co-digestion, can improve efficiency and increase yields. The Biochemical Methane Potential (BMP) of feedstocks or blends can be estimated using certain physical parameters or measured directly at the lab scale to indicate the viability of the process and allow for optimisation.

Gate fees can be charged for industrial and municipal wastes to offset some of the feed and pre-treatment costs.

7.5.6 Output

The AD process produces a biogas which can then be burnt in an engine to produce heat and electricty, or the gas can be upgraded or refined in quality for use in the national gas network or as a vehicle fuel. If supplied to an engine, the biogas can be used to produce heat directly in a gas boiler at efficiencies of up to 90%, or to produce (electrical) power in a CHP (combined heat and power) unit, from which heat can also be derived with efficiencies of around 80%. The power produced can be used on site or sold to the national grid. There are incentives available to improve the per-unit price that can be realised, dependent on the size and location of the project. Heat from the various generators is used to maintain the digester at its operating temperature and excess heat can be used for various other on site demands (steam generation) or distributed for local (6-8Km) needs.

7.5.7 Anaerobic Digestion SWOT Analysis

Strengths:	• Gate fees for AD to complement revenues from farm-based Animal By-Product regulations and increase biogas yields. • Improves environmental performance and economics of local waste management.
Weaknesses:	• Disposal of digestate subject to complex regulations and limitations • Scale of municipal waste resource is limited locally, impacting on technological options and capital and O&M costs. • Should be considered in a mixed feedstock facility with agricultural or industrial base.
Opportunities:	• New regulation requiring segregation and separate

	collection of food waste from relevant businesses. • Increased environmental benefit from AD compared to composting, with possibility to integrate both treatment channels. • Secure supply contract with public authority's waste collection and treatment activities in the area.
Threats:	• Competition from waste operators who can endanger revenues (gate fees) and supply chain. • Changes in regulation

7.5.8 Gas Upgrading

If the output gas is upgraded to 95%+ methane content it can be sold for injection to the national gas grid or local gas grid in the future and/or be used for vehicle fuel, on or off site. Apart from methane and carbon dioxide, biogas can also contain water, hydrogen sulphide, nitrogen, oxygen, ammonia, siloxanes and particles. The concentrations of these impurities are dependent on the composition of the substrate from which the gas was produced. In those upgrading technologies where carbon dioxide is separated from the biogas, some of the other unwanted compounds are also separated. However, to prevent corrosion and mechanical wear of the upgrading equipment itself, it can be advantageous to clean the gas before the upgrading.

- Removal of water: When leaving the digester, biogas is saturated with water vapour, and this water may condensate in gas pipelines and cause corrosion. Water can be removed by cooling, compression, absorption or adsorption. By increasing the pressure or decreasing the temperature, water will condensate from the biogas and can thereby be removed. Cooling can be simply achieved by burying the gas line equipped with a condensate trap in the soil. Water can also be removed by adsorption using e.g. SiO_2, activated carbon or molecular sieves. These materials are usually regenerated by e.g. heating or by a decrease in pressure. Other technologies for water removal are absorption in glycol solutions or the use of hygroscopic salts.

- Removal of hydrogen sulphide: Hydrogen sulphide is formed during microbiological reduction of sulphur containing compounds (sulphates, peptides, amino acids). The concentrations of hydrogen sulphide in the biogas can be decreased either by precipitation in the digester liquid or by treating the gas either in a stand-alone vessel or while removing carbon dioxide.
- Precipitation: Addition of Fe^{2+} ions or Fe^{3+} ions in the form of e.g. $FeCl_2$, $FeCl_3$ or $FeSO_4$, to the digester precipitates the almost insoluble iron sulphide that is removed together with the digestate. The method is primarily used in digesters with high sulphur concentration as a first measure or in cases where H_2S in the biogas is allowed to be high (e.g. higher than 1.000 ppm). For the removal of H2S from biogas, several technologies have been developed that will be described below.
- Adsorption on activated carbon: Hydrogen sulphide is adsorbed on the inner surfaces of engineered activated carbon with defined pore sizes. Addition of oxygen (in the presence of water) oxidises H_2S to plain sulphur that binds to the surface. In order to increase the speed of the reaction and the total load, the activated carbon is either impregnated or doped (by addition of a reactive species before formation of the activated carbon) with permanganate or potassium iodide (KI), potassium carbonate (K_2CO_3) or zinc oxide (ZnO) as catalysers. For grid injection or utilisation as vehicle fuel, only marginal amounts of O_2 are allowed in the gas. Hence oxidation of the sulphur is not suitable. In those cases mostly KI-doped carbon or permanganate impregnated carbon is used because addition of oxygen is not required in the case of KI under reduced loading. While ZnO impregnated carbon is rather expensive, H_2S removal is extremely efficient with resulting concentrations of less than 1ppm.

- Chemical Absorption: One of the oldest methods of H_2S removal involves sodium hydroxide (NaOH) washing. Because of the high technical requirement to deal with the caustic solution, it's application is hardly applied anymore except when very large gas volumes are treated or high concentrations of H_2S are present. Hydrogen sulphide can also be adsorbed using iron oxide-coated ($Fe(OH)_3$ or Fe_2O_3) support material (mostly pressed minerals, sometimes wood chips). In this treatment biogas is passed through iron oxide-coated material. Regeneration is possible for a limited number of times (until the surface is covered with natural sulphur), after which the tower filling has to be renewed.
- Biological treatment: Hydrogen sulphide can be oxidized by microorganisms of the species Thiobacillus and Sulfolobus. The degradation requires oxygen and therefore a small amount of air (or pure oxygen if levels of nitrogen should be minimised) is added for biological desulphurisation to take place. The degradation can occur inside the digester and can be facilitated by immobilising the microorganisms occurring naturally in the digestate.
- Removal of ammonia: Ammonia is formed during the degradation of proteins. The amounts that are present in the gas are dependent upon the substrate composition and the pH in the digester. Ammonia is usually separated when the gas is dried or when it is upgraded. A separate cleaning step is therefore usually not necessary.
- Removal of siloxanes: Siloxanes are compounds containing a silicon-oxygen bond. They are used in products such as deodorants and shampoos, and can therefore be found in biogas from sewage sludge treatment plants and in landfill gas. When siloxanes are burned, silicon oxide, a white powder is formed, which can create a problem in gas engines. Siloxanes can be removed by cooling the gas, by adsorption on activated carbon (spent after use), activated aluminium or silica gel, or by

absorption in liquid mixtures of hydrocarbons. Siloxanes can also be removed whilst separating hydrogen sulphide.

- Removal of particulates: Particulates can be present in biogas and landfill gas and can cause mechanical wear in gas engines and gas turbines. Particulates that are present in the biogas are separated by mechanical filters.

The by-product of the AD process is spent digestate, which still contains a small residual biochemical methane potential. This digestate may have a value as a fertiliser in certain circumstances but there are strict legislative controls as to its disposal or end use. It could also be pelletised and used as feed for a centralised heat and power plant.

AD plants can vary in size and output, ranging from domestic scale, (1 or 2 households, mainly found in the developing world) to large scale industrial, supplying power to tens of thousands of households. A typical small farm or industrial plant might employ a 70-500 KWe engine, operating in a local area with locally sourced feedstocks. Larger scale plants, 0.5-1.5 MWe or greater, must be carefully planned and managed due to feed and waste transport costs.

Certain factors such as proximity to power or gas grid connections, or the availability of incentives and tariffs, plus the availability of a secure supply of feedstock will help in the planning of the type and nature of plant that can be financially viable.

7.6 Wind Turbines

Northern Ireland is regarded as having one of the greatest wind energy resources in Europe. It is important that the potential of this resource is maximised to contribute to an increase in the proportion of our energy that is derived from renewable sources. The wind resource within Northern Ireland is very significant and the predicted mean wind speed and power in many such locations is in the range of 8 to 10.5 metres per second which is regarded as sufficient to support economical wind energy projects. In order to determine if a location has potential for wind development a number of additional factors have to be accounted for. These will be outlined within this report.

For the businesses and community within the Draperstown area the potential of installation of single and multiple wind turbine sites will be obvious, namely:

- Wind turbines will help to reduce / cut electricity bills
- Financial incentives are available e.g. ROCs on the electricity generated
- Potential to use what is needed and sell the rest back to the grid.
- Reducing carbon footprint, wind turbines are a green technology, which emit no harmful Green House Gases (GHG).

The following key factors for any potential wind development are:

- Planning
- Wind Resource / Speed
- Site selection/constraints
- Grid connection
- Project costs / Financial returns

The report will not investigate sites on an individual basis, however will seek to provide insight into where the best potential sites may be located. If individual sites are subsequently identified by recipients of the report a full wind feasibility study of the site should be commissioned.

The primary focus of the analysis is on the 5km radial distance from the electricity substation located at (Figure 9). Wind development sites within this boundary offer an increased opportunity for favourable grid connection terms from NIE. The 5km radial boundary includes Draperstown and the villages of Lisnamuck, Tobermore, Straw and Moneyneany. (Figure 10) All the associated businesses fall within the 1km radial distance from the substation (Figure 11), with the majority of businesses being densely distributed within Draperstown village; the exception being Sperrin Galvinisers which is adjacent to the

Substation.

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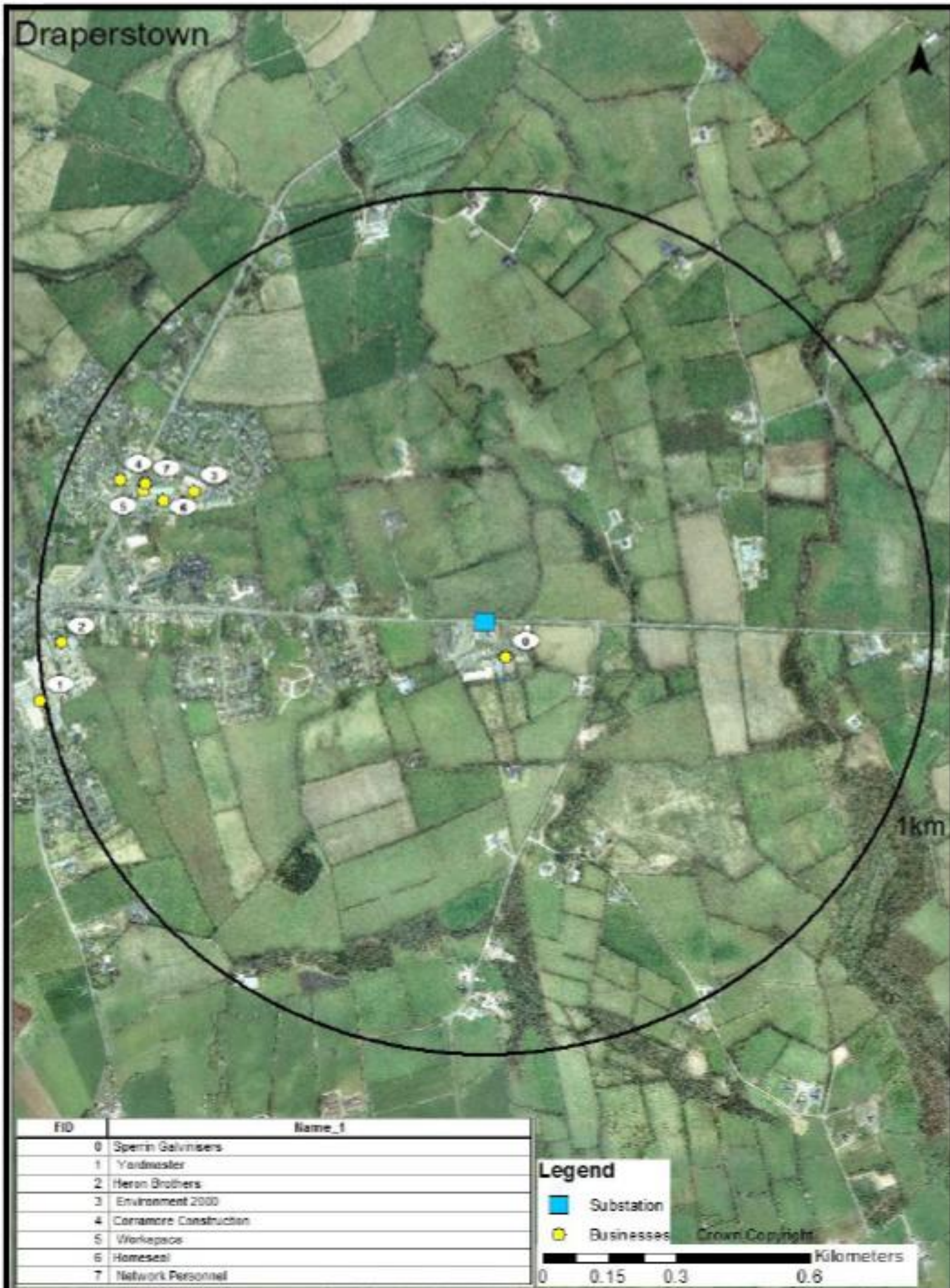
Draperstown
1km
FID
Name_1
0 Sperrin Galvinisers
1 Yardmaster
2 Heron Brothers
3 Environment 2000
4 Corramore Construction
5 Workspace
6 Homeseal
7 Network Personnel
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Figure 12)

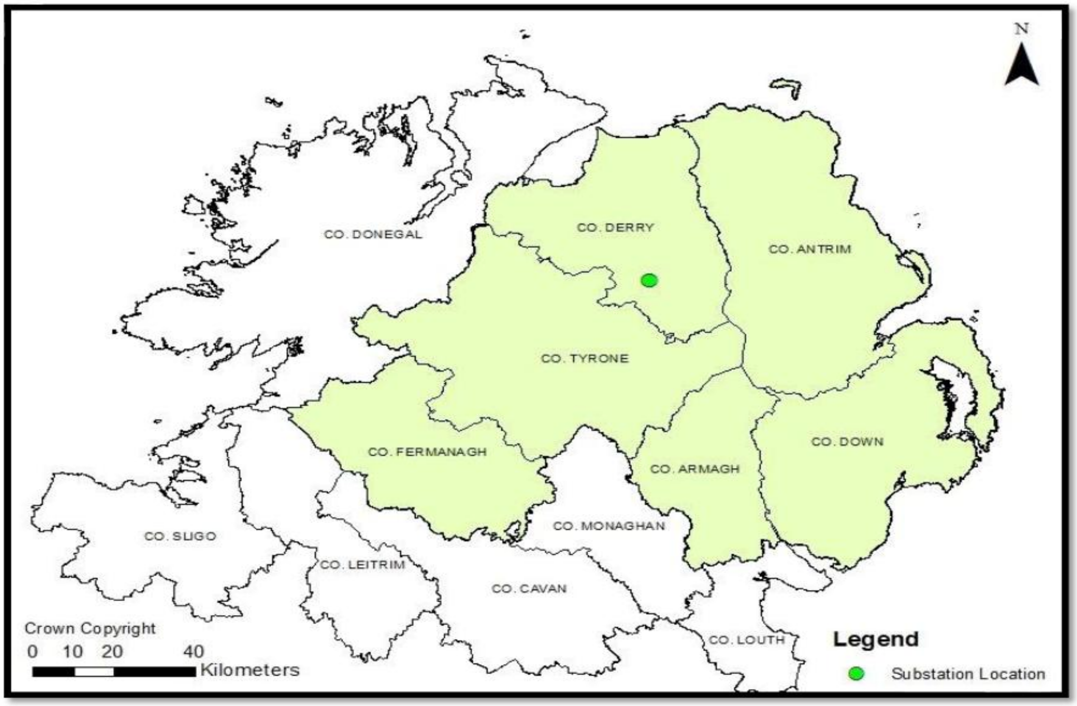


Figure 9 Substation location

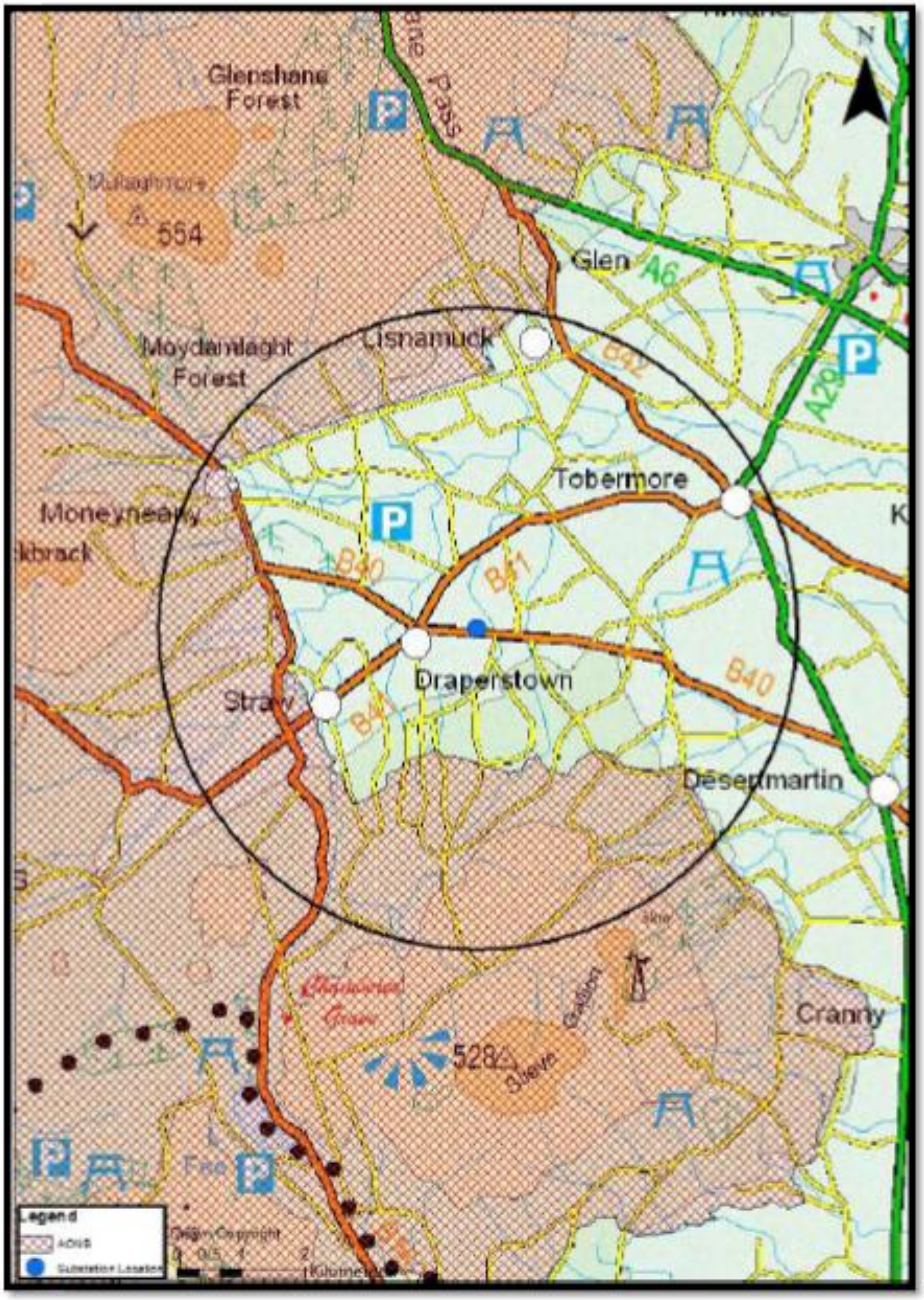


Figure 10 NIE Substation location & Sperrins AONB

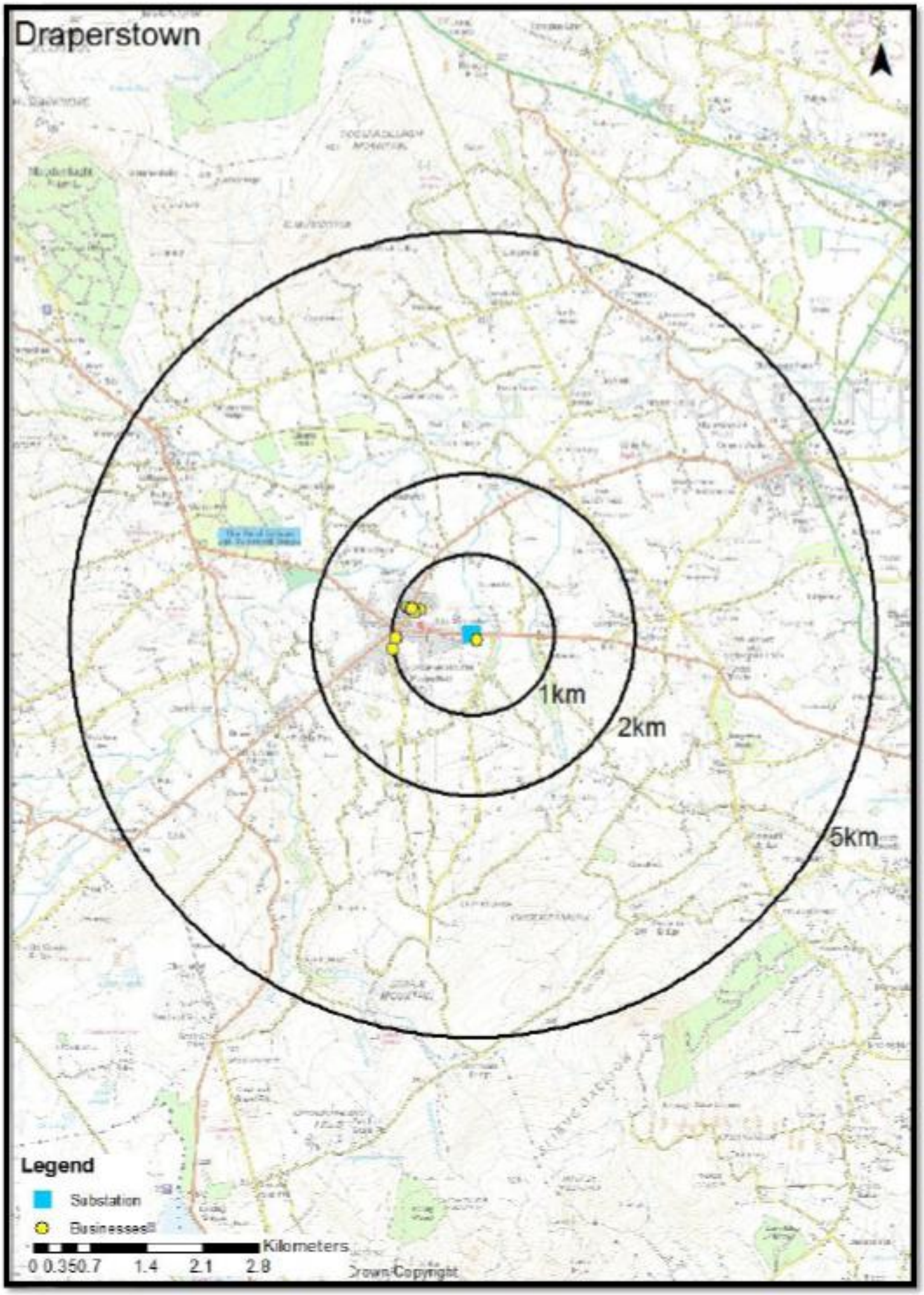


Figure 11 Radial Buffer of Substation & Location of Businesses

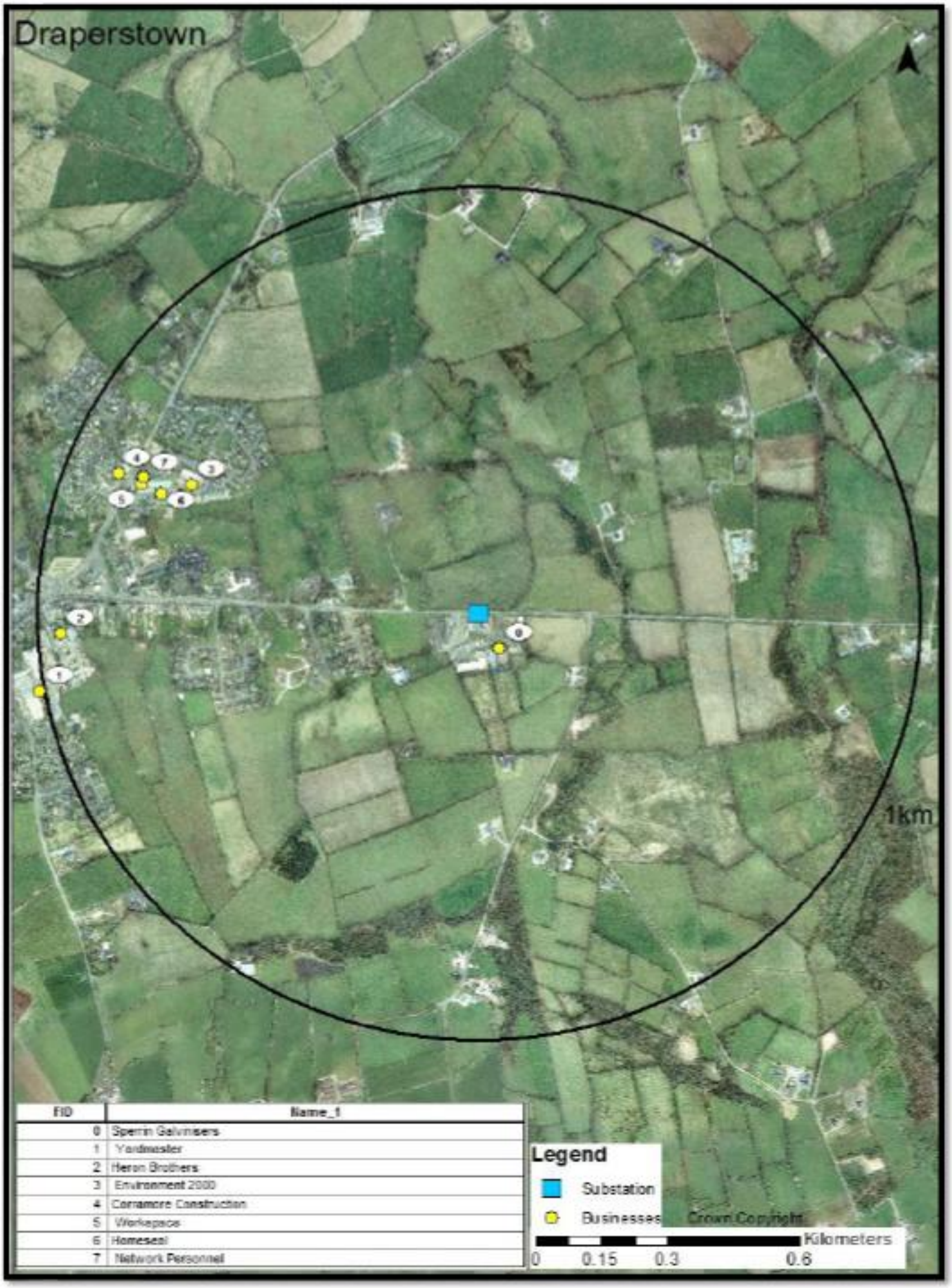


Figure 12 Businesses

7.6.1 Land-Use (for Wind Turbine purposes)

The most prominent land classification within the study area is the land designated within the Sperrins Area of Outstanding Natural Beauty (AONB). This intrudes on the 5km buffer along the northern, southern and western fringes. Due to the special classification of this area, any development within this boundary is high unlikely, therefore the possible location area within the buffer is lessened to 4,888ha. If this is advanced further, wind turbines are often not permitted within 500m of a dwelling (depending on their size – see 7.6.6 section on noise). If this buffer is applied and deducted from the potential area mass, the potential development area falls to approximately 2981.75ha. (Figure 13). It can be noted that if a turbine development exclusion zone of 500m is considered for each property there are no cases where development can take place where the installation can be located the required distance from a dwelling. Within a 2km radius of the substation there are a total of 3,868 buildings, with 49.45% of these classified as house dwellings (1,913). A complete breakdown of building classifications can be seen in Figure 14.

In the area surrounding the substation location there are various forms of land-use apparent in the area. This information has been developed from the 2006, Co-ordination of Information on the Environment (CORINE) project, which examined the land cover and usage over several European countries. Excluding the land designated within the Sperrins AONB, the main land-use is related to agriculture, with pastured land, land containing complex cultivation patterns and specific agricultural land identified. In addition to this, it is important to acknowledge areas where development may not be possible such as in areas of built land or peat bog. (Figure 15)

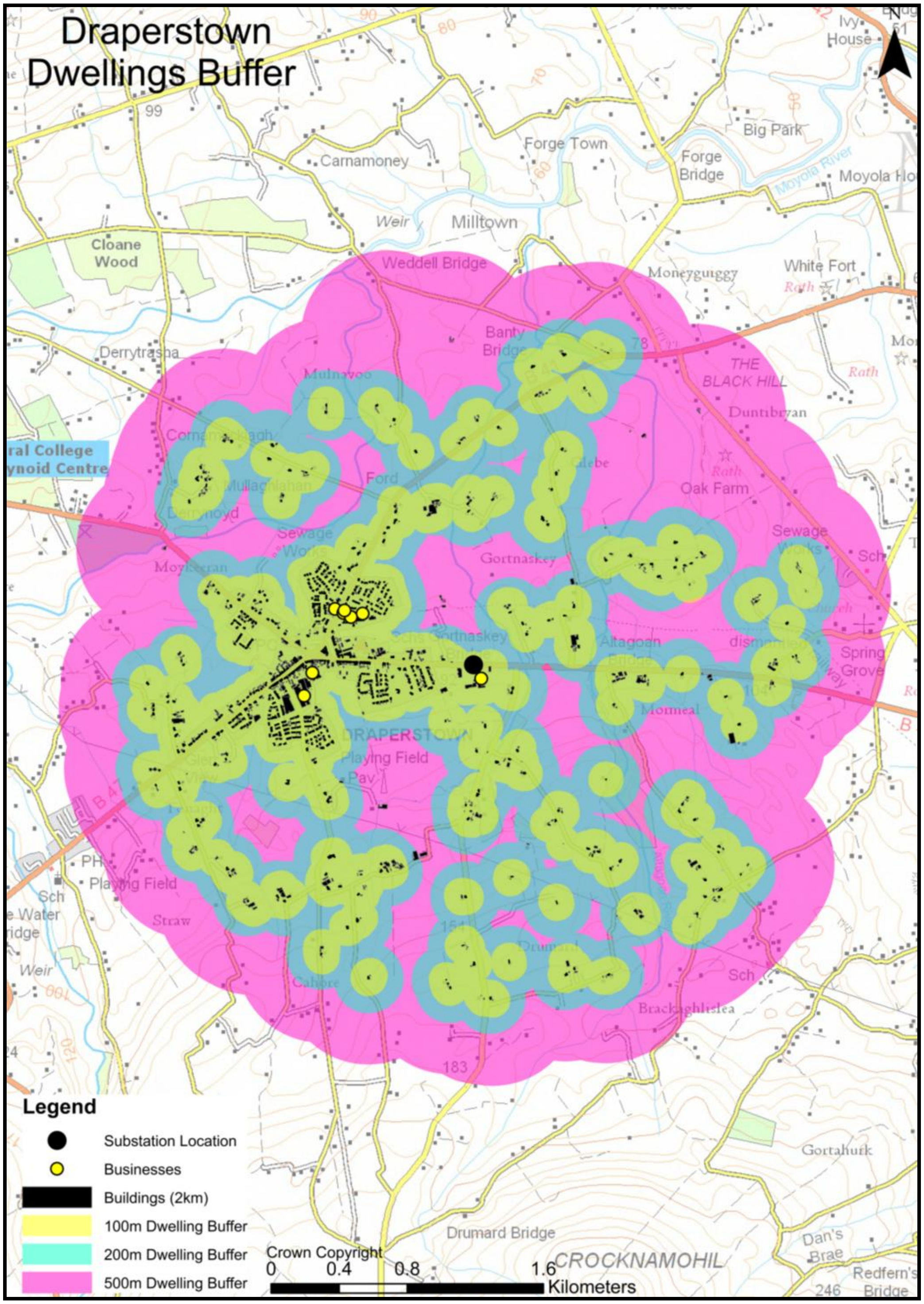


Figure 13 500m wind development exclusion zone shown in relation to existing dwellings

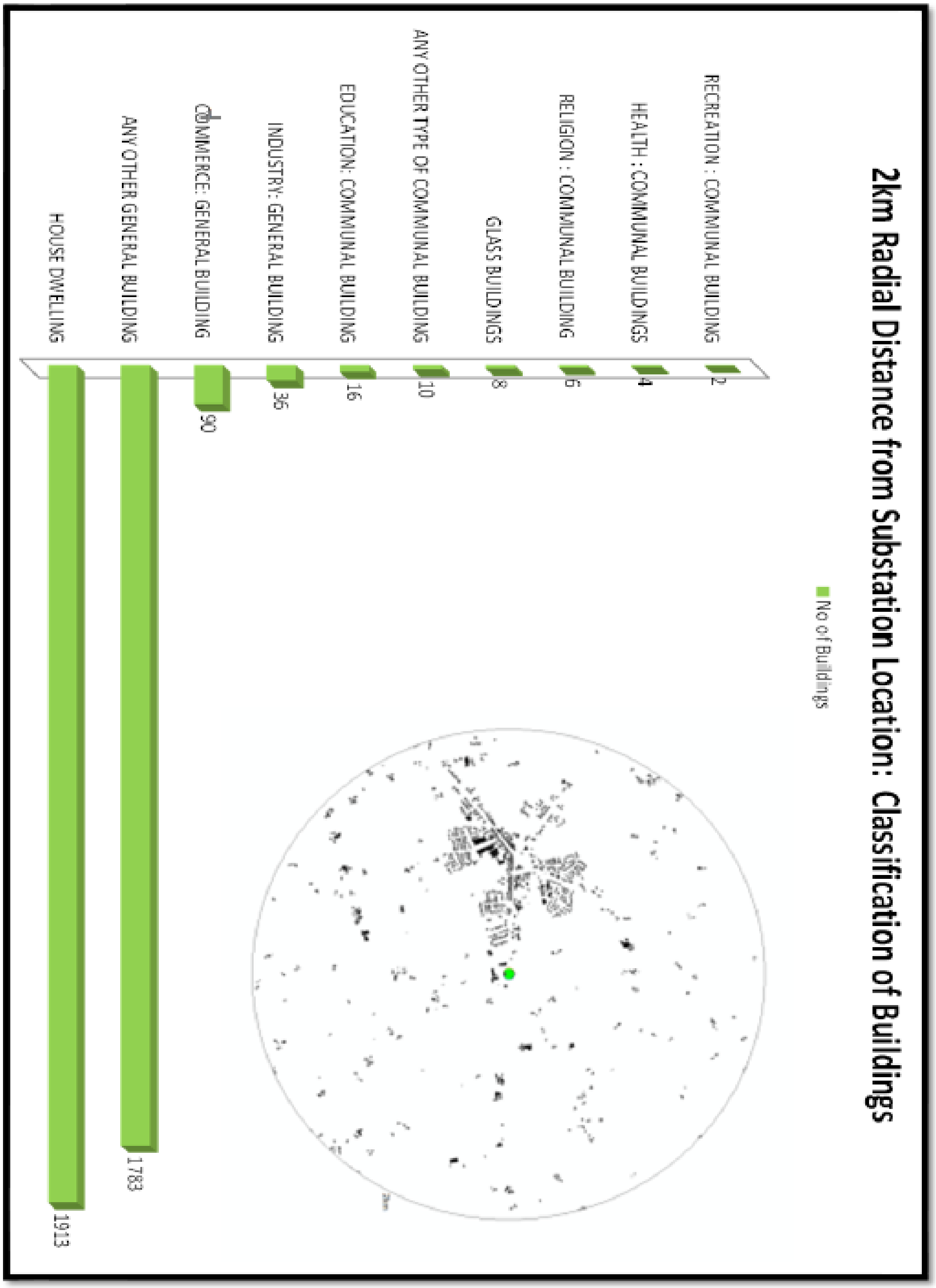


Figure 14 Buildings Classification

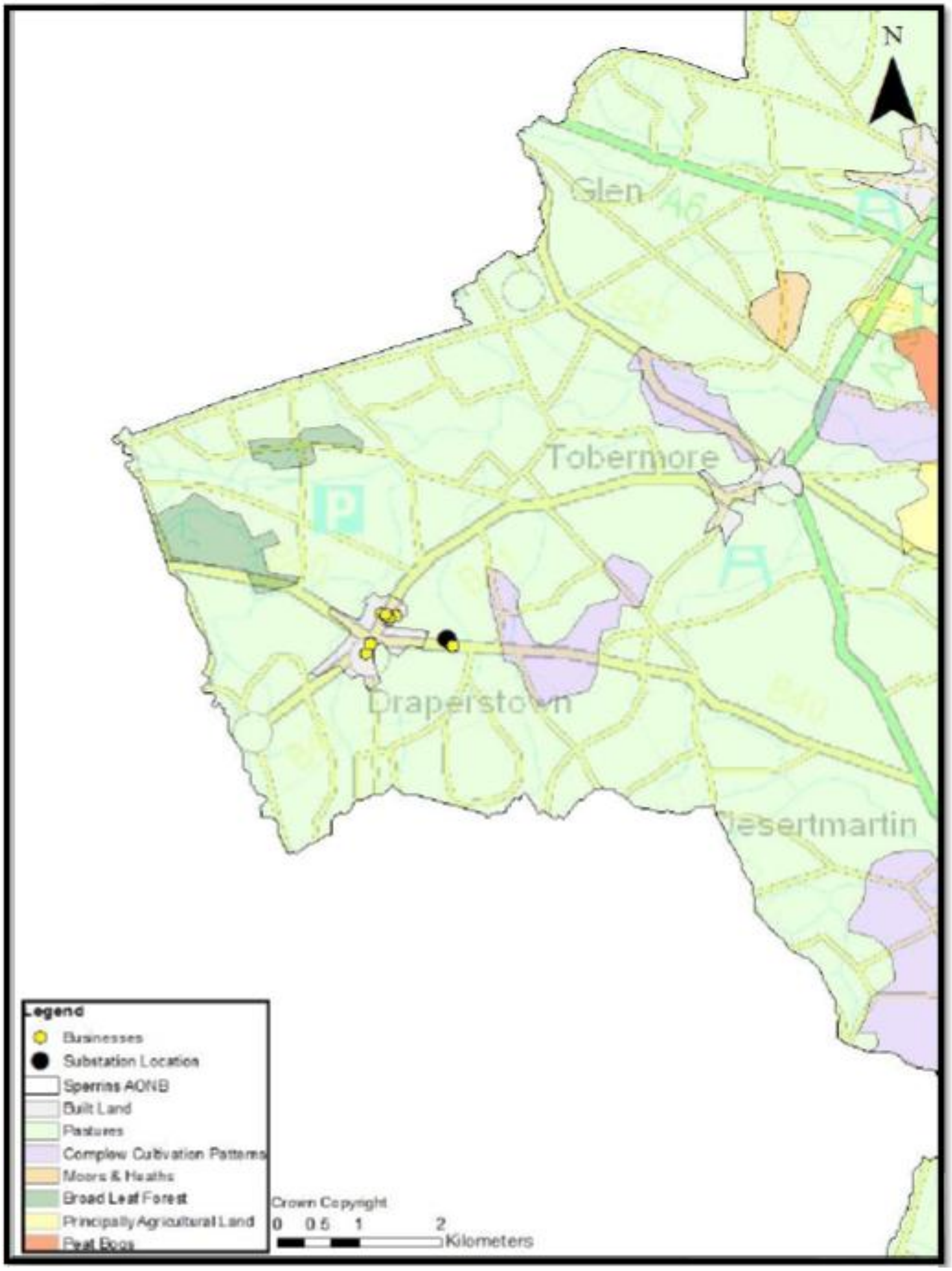


Figure 15 Corine Land Use

7.6.2 Landscape

The physical landscape is an important element in the consideration of wind turbine placement, with the orientation of elevated areas prominent in the supply of wind energy and subsequent success of the installation. In order to analyse this, it is important to evaluate the elevation, slope and aspect for the area in question; the focus in this case being any area within a 5km radius of the substation location. The elevation for the area was developed through the creation of a Digital Terrain Model (DTM) using 50m point data; this was necessary in order to interpolate the values of the area between points.

From the DTM created (Figure 16) it is apparent that the least elevated land is in the area immediately surrounding the substation, encompassing the associated businesses and Draperstown village. There are elevated areas within the 5km buffer however, with the most significant increase in the area south of the substation. There is also the indication of increased gradient in the north and to a lesser extent to the west. These locations draw similarities to the defined boundary of the Sperrins AONB .

Following the creation of a DTM for the area it is possible to determine the slope gradient within the landscape. This is based on the maximum rate of change in the z-value for each cell and is developed by assigning a value to each cell on a raster surface, based on the elevation and the rate of change between these elevation cells. The slope algorithm was developed for the area within the 5km buffer only, therefore the areas outside of this, although developed, will not be accurate.

The slope illustration developed (Figure 17) highlights the changes in elevation within the landscape identified with the DTM created previously. The extent of the elevated area in the south is clearly noted while the generally flat land in the immediate area around the substation is also apparent. The eastern boundary of the buffer, given the restriction of the Sperrins AONB, would appear as the only possible area for development but based on the data presented through the DTM (Figure 16) and the slope map (Figure 17) it is highly likely that this area would not be viable as it is generally flat land flanked on the north, south and west with land of greater elevation. This is also supported through the aspect map (Figure 20) also developed from the DTM created. The aspect and slope are intrinsically linked with the aspect regarded as the direction of the slope, while the previous slope map (Figure 17) illustrating the degree at which the slope occurs. The equation used in this instance identifies the downslope direction of the maximum rate of change in value from each cell to its neighbour; this value is then displayed as the compass direction. As was the case with the slope map, it is important to note the area outside of the 5km was not included in the analysis therefore the aspect will not be accurate in those locations. By examination of the output, the blue and green hues to the north indicate that the slope faces south and south-east, whilst there is a concentration of red and pink hues to the south indicating the slope in this region faces north and north-west.

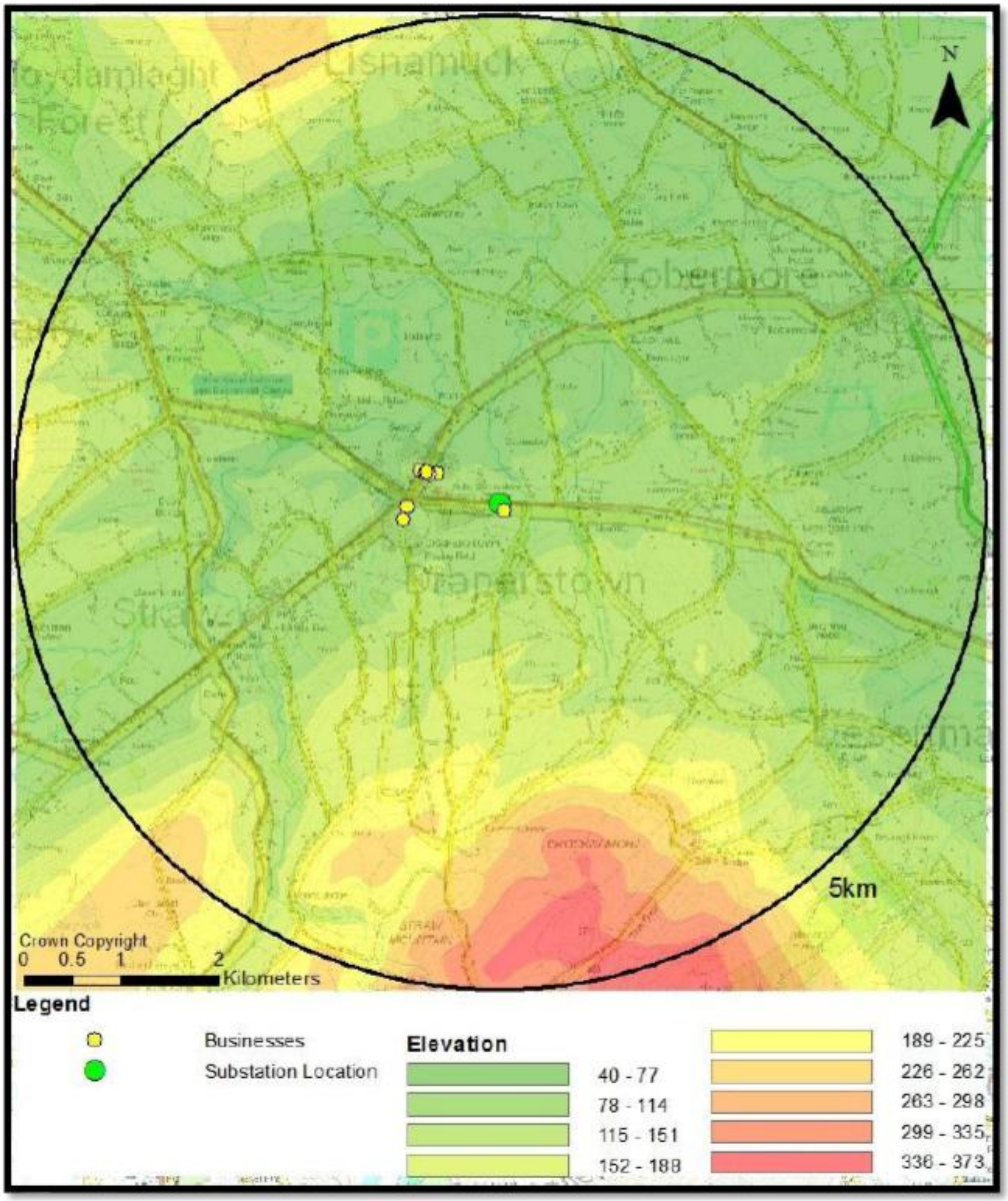


Figure 16 Landscape Elevation

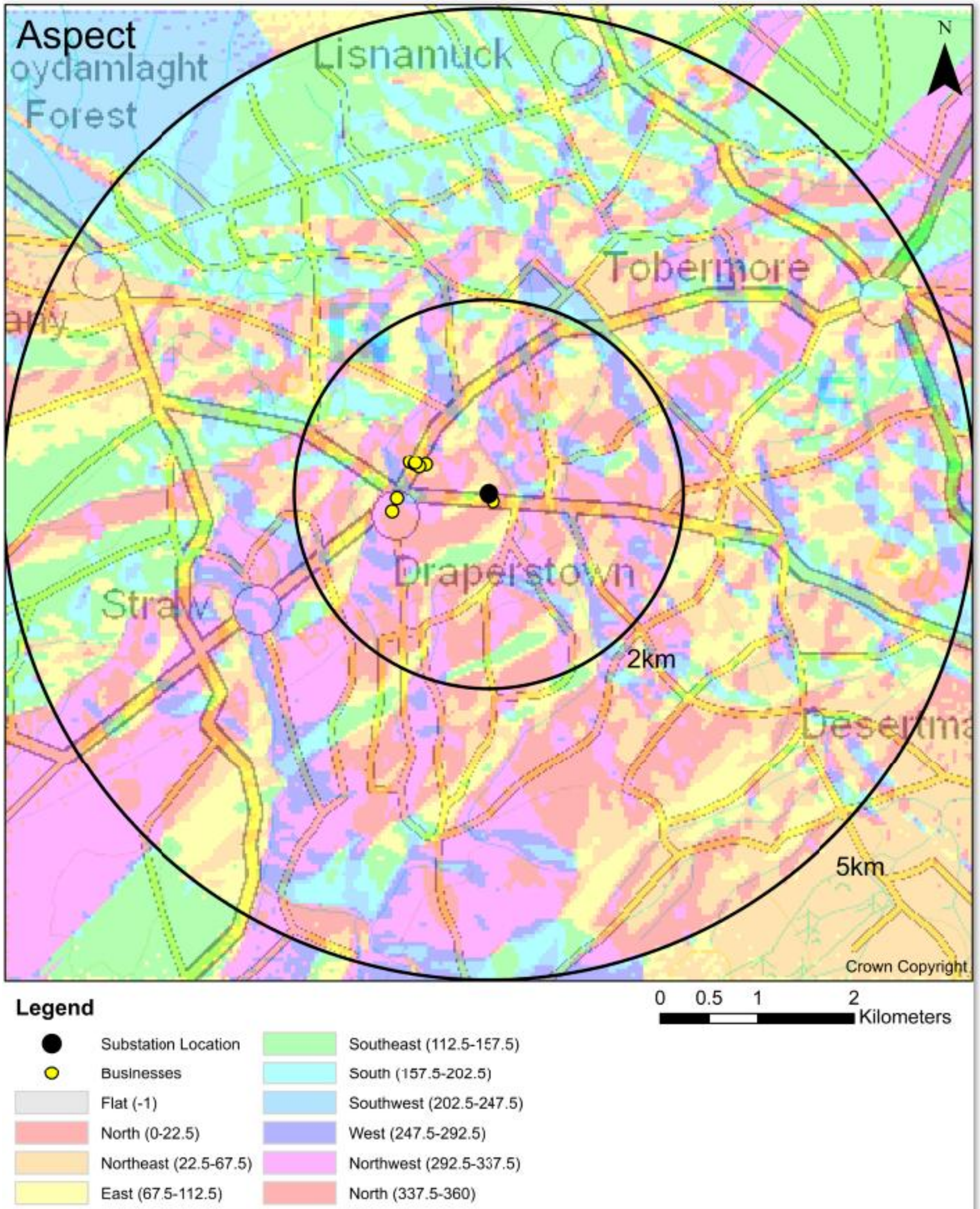


Figure 17 Slope Map

7.6.3 Wind Speed

Wind speed data is important in making a decision on whether the site is suitable for the purchase of a wind turbine. The best sites for wind development will have an average wind speed in excess of 7m/s. The Department of Energy & Climate Change (DECC) provide an online Windspeed database[1] which provides estimates of the annual mean wind speed throughout the UK. It should be noted that when using this data:

- The data uses an air flow model to estimate the effect of topography on wind speed.
- There is no allowance for the effect of local winds such as sea, mountain or valley breezes.
- The model uses a 1 kilometre square resolution and does not take account of topography on a small scale, or local surface roughness (such as tall crops, stone walls or trees), which may have a considerable effect on the wind speed.
- The data should be used as a guide only and should be followed by on-site measurements for a proper assessment.
- Each value stored in the database is the estimated average for a 1 kilometre square area, at either 10 metres, 25 metres or 45 metres above ground level (agl).
- The database uses the Ordnance Survey grid system for Great Britain and the grid system of the Ordnance Survey of Northern Ireland

For the purposes of this study Wind speed data was obtained from DECC, similarly to the elevation data this was also in the form of point data but through the Inverse Distance Weighting (IDW) function noted previously, the data was

[1] http://tools.decc.gov.uk/en/windspeed/default.aspx

interpolated and outputs developed. The data obtained included wind speed values at various heights above the ground, primarily at 25 and 45 metres. The intensity of wind speed at both heights generally reflect the elevation of landscape, this can be seen in the wind speed map for Northern Ireland at 25m (Figure 18) where it is possible to identify highly elevated areas such as the Glens of Antrim in the north-east, the Mourne mountains in south county Down and the Sperrin Mountains in counties Londonderry & Tyrone.

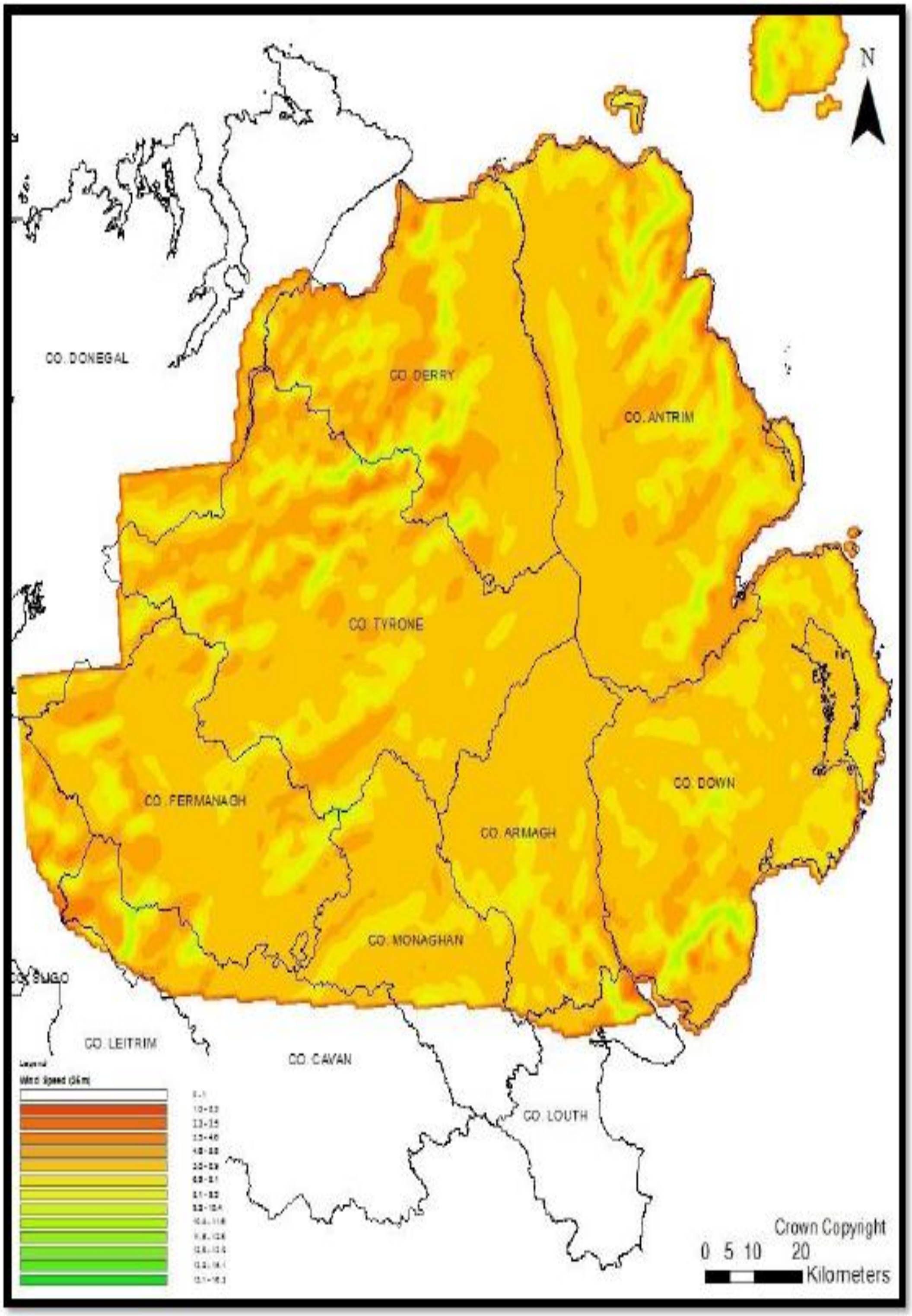
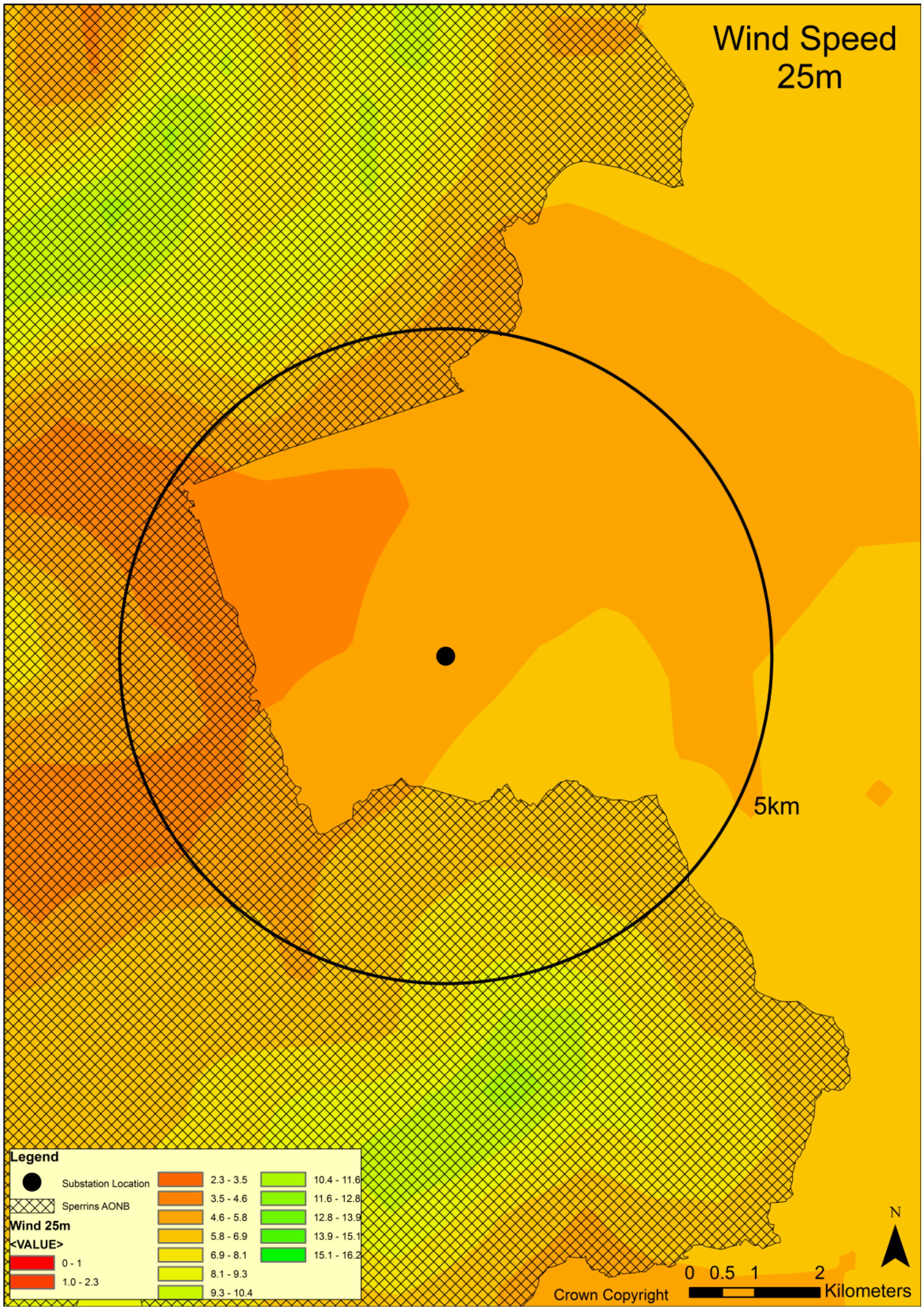


Figure 18 Wind Speed Northern Ireland (25m)

This intensity of variation between wind speed values reflects the relief of the landscape with the maximum values obtained on the highest areas and a sudden dip in value noticeable in adjacent areas due to the shelter caused by this elevated area. This explains the variation between the green hues, indicating high wind speed, and the red hues, low wind speed, within close proximity to each other. Similar effects were noted when studying the specific area around the substation outside of Draperstown. Based on the analysis of the substation nestled in the foothills of the Sperrin Mountains, flanked on the north, south and west by parcels of elevated land, as a result the sharp variation in wind speed in such areas is also apparent in this instance. On both the map developed at 25m and at 45m (Figure 19) the disparity in high to low (green to red hues) values is evident within the small scale environment in question; this results in wind speed values within the 5km buffer (from the substation- see Grid Connection Section) for 25m and 45m being 3.5ms-6.9ms and 4.6-9.3ms respectively, whilst areas in very close proximity to the buffer record wind speeds in excess of 10ms.


Wind Speed
25m
5km
Legend
Substation Location
Sperrins AONB
Wind 25m
<VALUE>
0 - 1
1.0 - 2.3
2.3 - 3.5
3.5 - 4.6
4.6 - 5.8
5.8 - 6.9
6.9 - 8.1
8.1 - 9.3
9.3 - 10.4
10.4 - 11.6
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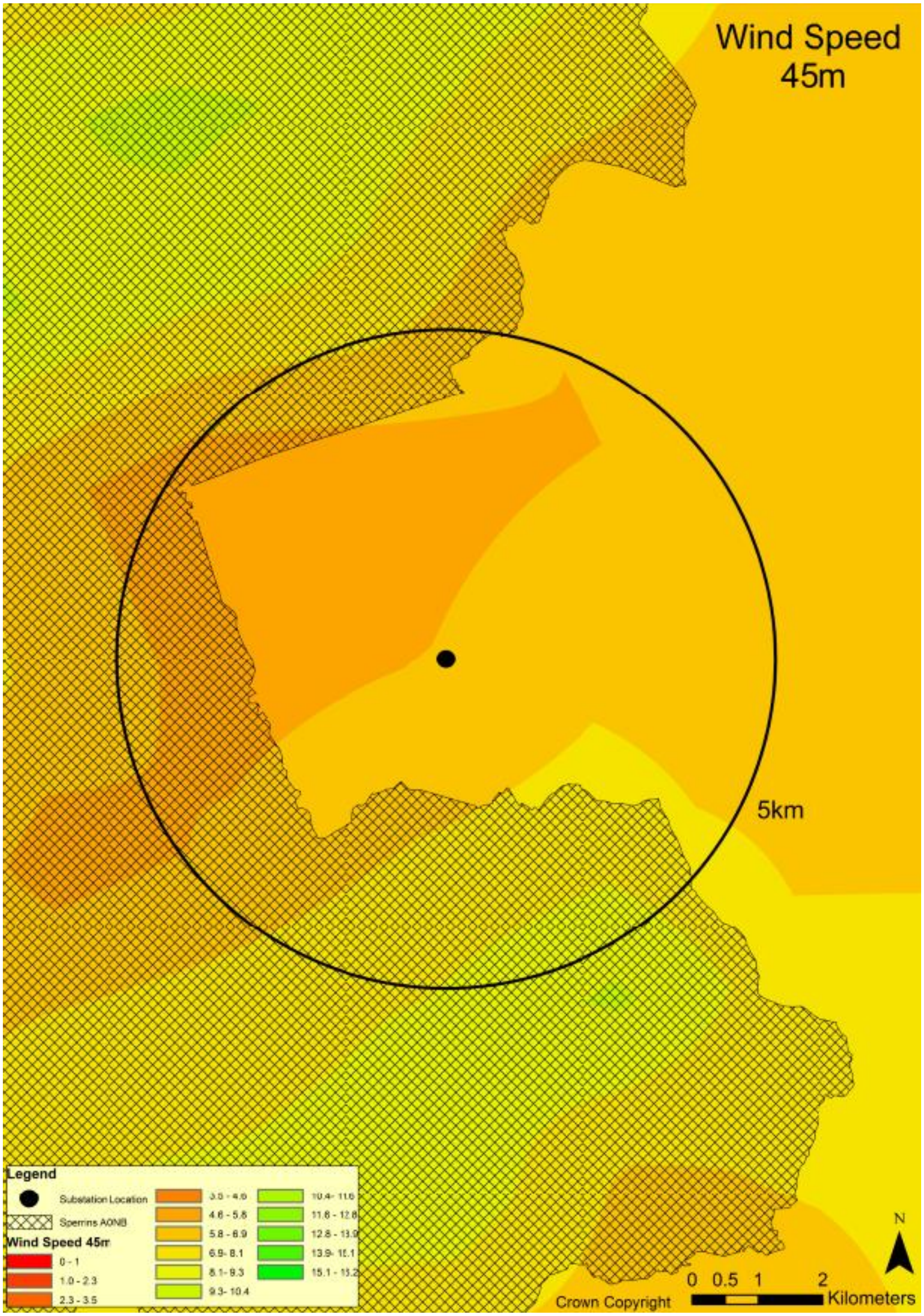


Figure 19 Wind Speed in Area (25m) and (45m) elevation

It is important to note the large variation of wind speed values between 45m and 25m (Figure 19); the same wind speed classification scale was used in both maps to allow for comparison and the scale of disproportion in the 25m output compared to the 45m equivalent shows the influence of elevation. This would also indicate that any wind turbine development within the 5km buffer would ideally need a tower in excess of 40m to obtain greater wind speeds and increase turbine productivity. A typical tower height for a 225kW turbine would be in the region of 40m. As indicated on the 40m map, the area in the south-east region (orange & yellow) of the 5km buffer zone (black circle) shows the most promising wind speeds (Orange 5.8-6.9m/s and yellow 6.9-8.1 m/s). Wind speeds in and around the town centre, where most businesses in this study are located are relatively low (4.6-5.8 m/s), and almost certainly more turbulent, and so here would not be deemed a good area for turbine location.

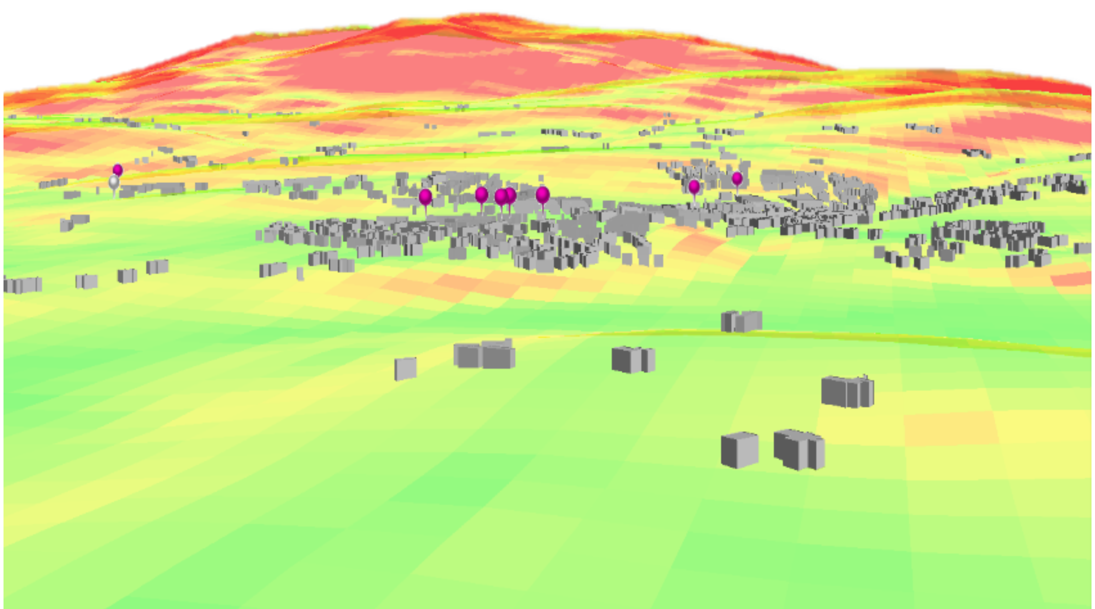


Figure 20 Draperstown & Slope Map (Looking South)

7.6.4 Planning & Wind Development in the Draperstown Area

The Planning Department’s Planning Policy Statement 18: Renewable Energy (PPS18) and the Best Practice Guidance to Planning Policy Statement 18: Renewable Energy divides Northern Ireland into a number of Landscape Charter Areas (LCAs) as indicated in the following map in order to facilitate the siting of renewable energy generating facilities in appropriate locations within the built and natural environment to help achieve Northern Ireland’s renewable energy targets and to realise the benefits of renewable energy.

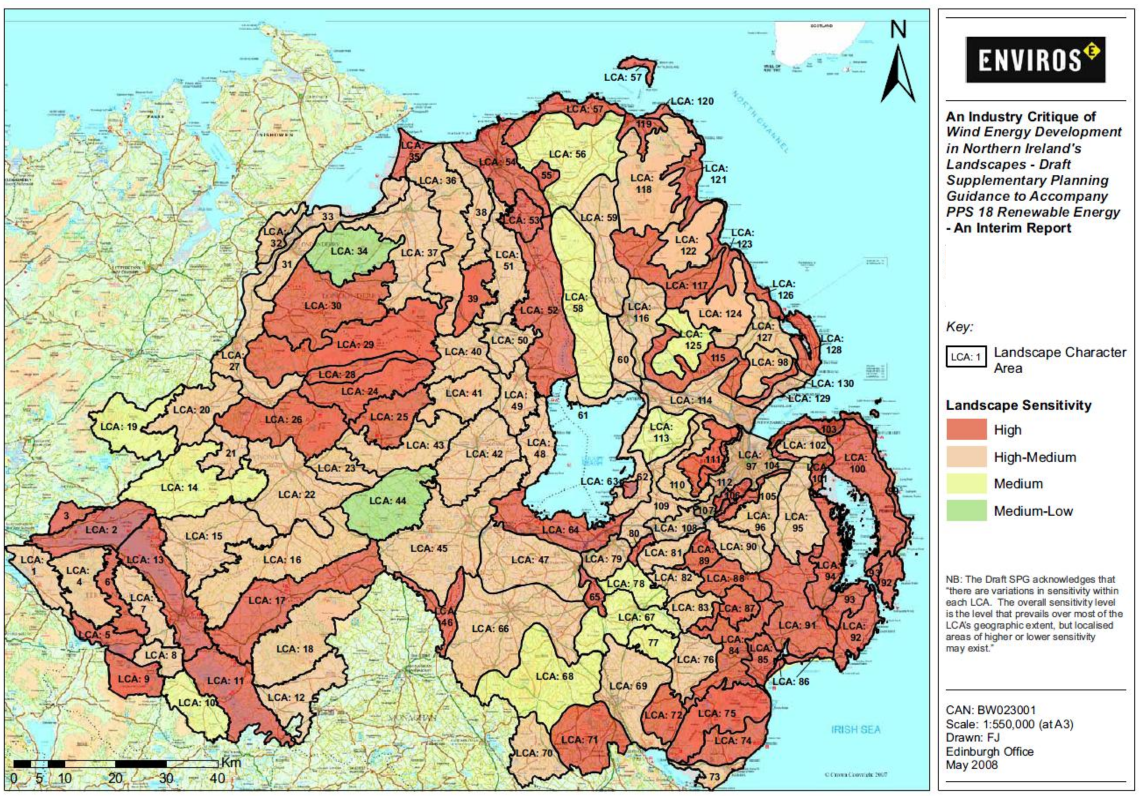


Figure 21 An Industrial critique of wind energy development in Northern Ireland

For each LCA a description of sensitivity against each of the criteria was prepared. The LCA was then given an overall sensitivity level using a five point scale:

High sensitivity	Landscape is very vulnerable to change and would be adversely affected by wind energy development, which would result in a significant change in landscape and visual characteristics and values.
High to medium sensitivity	
Medium sensitivity	
Medium to low sensitivity	
Low sensitivity	Landscape is not vulnerable to change and would not be adversely affected by wind energy development, which would not result in significant change in landscape and visual characteristics and values.

Figure 22 PPS18 Life cycle assessment

Within the PPS18 document an assessment is made for each LCA. The assessment for the Draperstown area is as follows:

Assessment for Wind Energy Development

Overall sensitivity

This LCA is characterised by its strongly enclosed, treed character and limited internal views which tend to reduce its sensitivity. This is however offset by the fact that there are many high-level views into the LCA. This landscape is sensitive to inappropriately scaled wind energy development. The least sensitive part of the LCA is the southern edge of the valley, on the lower slopes of Slieve Gallion.

Overall Sensitivity - High to medium

Location, siting, layout and design considerations

Fringe landscapes on the southern edge of the valley are the areas in this LCA that have the best capacity for some form of wind energy development.

Consideration could be given to siting turbines on mid slopes against a hillside backdrop. It is recommended that wind energy developments reflect the small scale of landform features. It is also recommended that attempts be made to minimise visual clutter where turbines would be seen in close proximity to electricity transmission lines.

Particular care should be taken to avoid adverse impacts on the setting of or approaches to the Sperrins. The degree of exposure of landscapes of the valley edges should be respected. At the time of assessment there were no operational or consented wind farms in this LCA.The nearest consented wind farm was at Long Mountain, more than 20km to the north-east.

Separation distance from any development in adjoining LCAs should be a consideration, notably Slieve Gallion LCA to the south.

Draperstown sits at the foot of the Sperrins, which is designated an Area of Outstanding Natural Beauty (AONBs) (Figure 23), and although this area offers the best wind resources in the region it is excluded from our assessment on the basis that any planning approval within this zone will be unlikely and highly controversial. That being said the authors are aware that approval has been granted to appeal a planning decision for a local wind farm within this region.

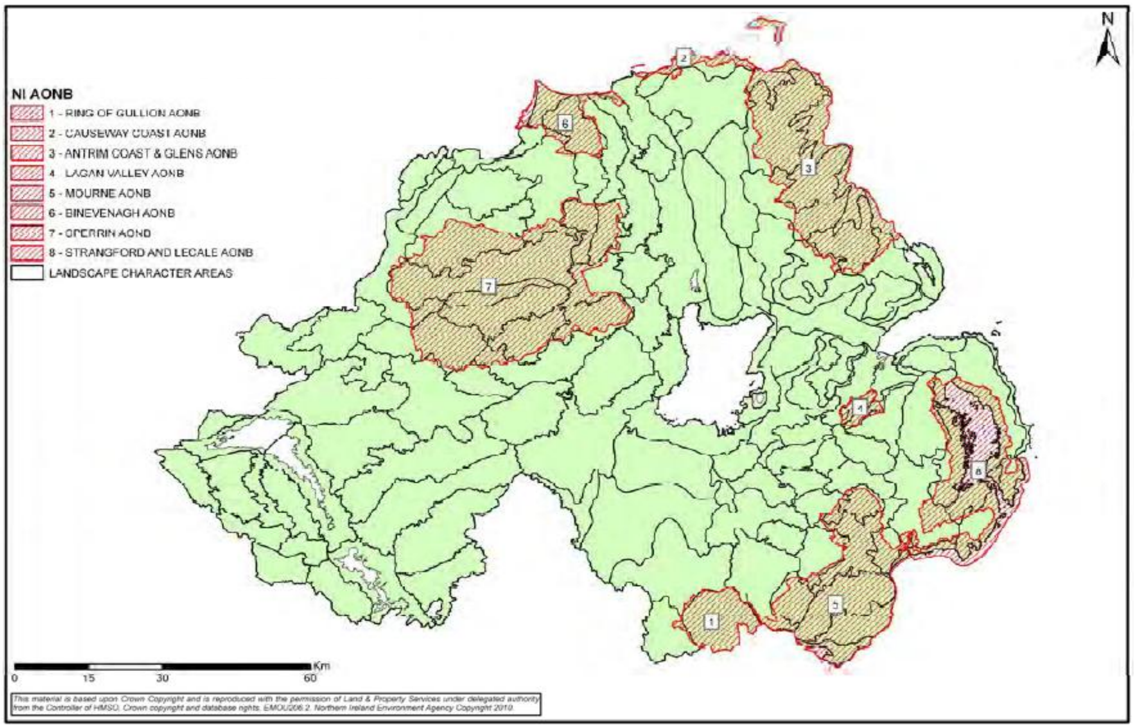


Figure 23 Northern Ireland Areas of Outstanding natural Beauty

The report for this judgement has been included below for reference purposes. It can be seen that the original application was made in 2004. In any event for the purposes of wind development for the community it would be advisable to exclude this area for the time being until the appeal is heard. Certainly it is unlikely that single wind turbine sites will be deemed of sufficient economic importance to mitigate against any environmental impact.

08/03/2013

The fast-growing wind energy sector in Northern Ireland was given a significant boost recently with a ground- breaking judgement in the High Court on the crucial balance between economic arguments and the views of those objecting to developments on visual and environmental grounds.

The judgement quashed a decision by the Planning Appeals Commission to refuse an application for a seven-turbine wind farm in the Sperrin Mountains, allowing the appeal to be reheard.

The application was originally submitted back in 2004, refused by the DOE Planning Service in 2007 and appealed to the PAC in 2011.

A specialist energy team from Belfast law firm Tughans acted for the applicants in the case, and have hailed the judgement as highly significant for the Northern Ireland wind farm industry.

“The judgement makes it clear that the economic benefits of a proposal are critical, even where potentially adverse impacts on the landscape have been identified by opponents of the proposal,” says Andrew Ryan, Head of Tughans Energy Team.

The Planning Appeals Commission had ruled that the visual impact of a wind farm in the Sperrins Area of Outstanding Natural Beauty would outweigh any potential economic benefits....including a green contribution to energy output and associated benefits for the local economy.

But, in the High Court judicial review, the Tughans team argued that the Commission had failed to properly consider the economic benefits, and the farm's contribution to the 2012 Northern Ireland-wide target of 12% renewable energy generation.

The trial judge, Mr. Justice Treacy, concluded that the “flawed assessment tainted the balancing exercise which involves weighing adverse impact against, inter alia, economic benefits”.

“This judgement should be carefully reviewed and considered by anyone involved in promoting renewable energy development,” says Andrew Ryan. “Given the number of planning applications for renewable energy development in Northern Ireland, the decision is of paramount importance in shaping how the policy will be interpreted in future applications and appeals.”

Total wind resources in this LCA (41) have been calculated at between 6 MW and 13MW (Figure 24), depending on the view taken by planning authorities, which indicates that there is significant potential (dependent on grid connection) in the area.

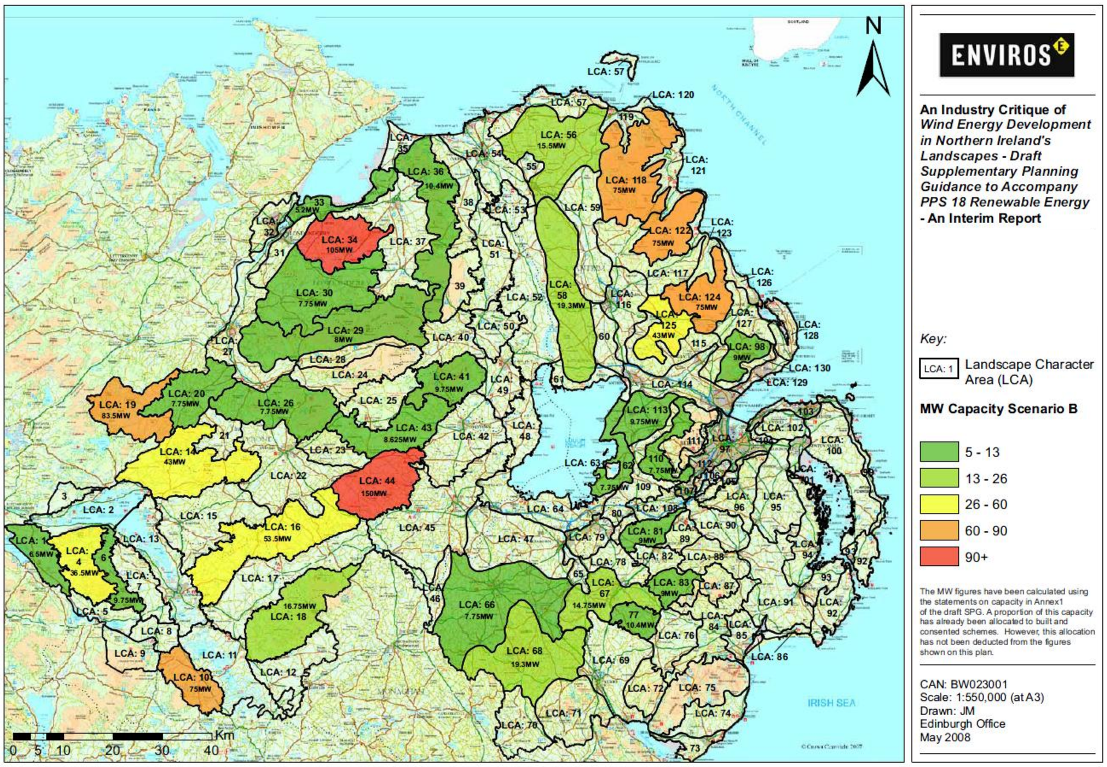


Figure 24 Wind energy development in Northern Ireland

Planning permission will factor in the following issues: visual impact, ecological impact, noise, shadow flicker and land designation i.e. located away from e.g. AONB (areas of outstanding Natural Beauty.)

7.6.5 Mapping Site Constraints

Once the wind speed from a potential site has been properly assessed over 12 months of anemometer data and overall planning potential of the region assessed, there are other factors that may prevent planning being granted. These factors are outlined below and would need a full site assessment conducted to evaluate their potential impact on a project. These site specific constraints such as noise, hedgerow etc. are typically used to produce a site map that clearly shows the area available for wind development.

7.6.6 Noise Propagation

Noise propagation can be one of the main factors to consider when sitting a turbine. A rule of thumb previously was that the turbine had to be some 10xturbine power rating distance from the nearest dwelling. Now it is assessed more on the dB level. This means that for even a small turbine (10kW), the distance required from dwellings can be around 200m. A distance of around 350m is usually sufficient for a larger turbine (225kW). This could be less depending on sound level measurements.

When the exclusion zone is applied to the local region the resulting map (Figure 25) shows a much smaller area suitable for wind turbines than people would anticipate, but it is an important factor when assessing the wind development potential of a site.

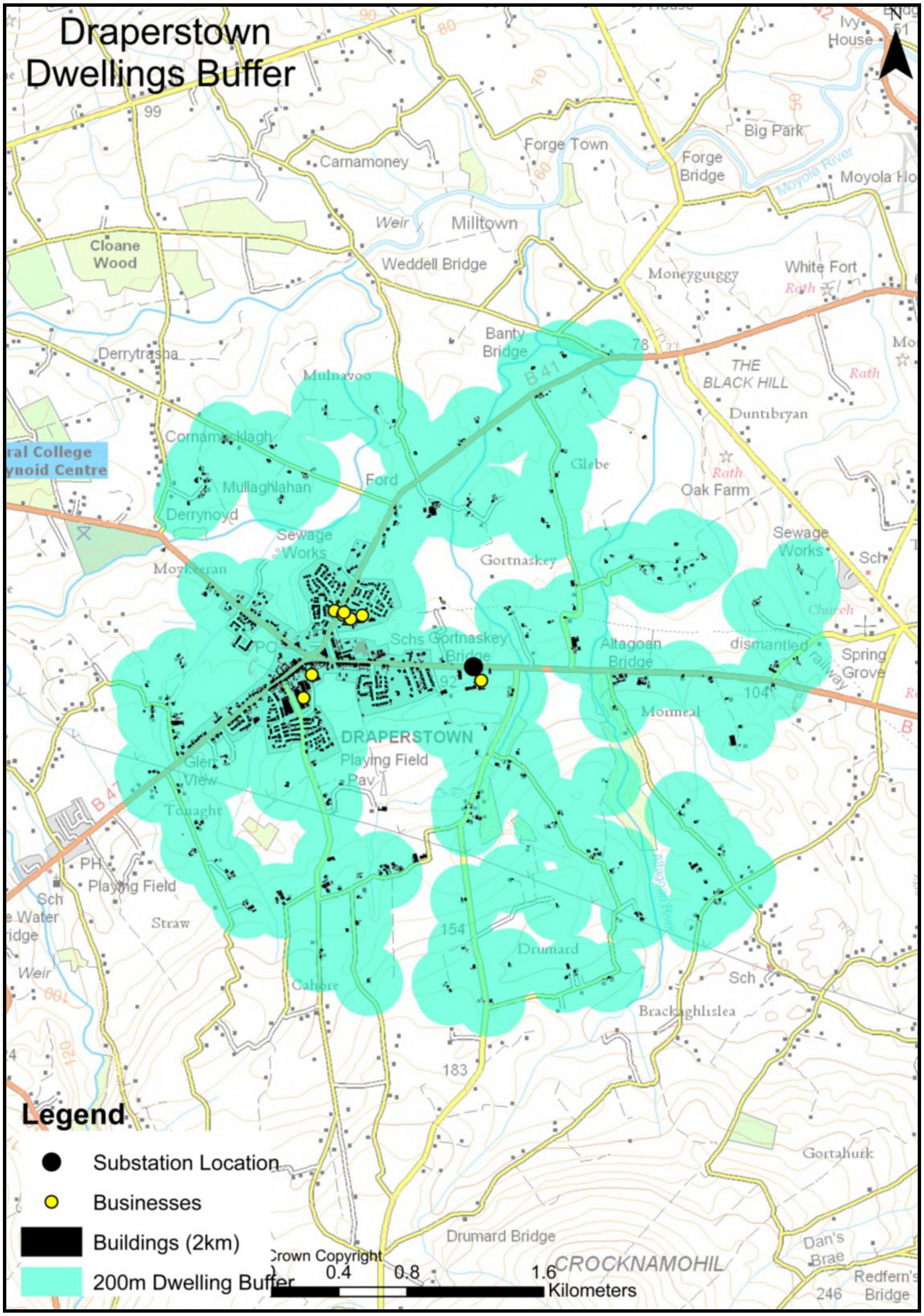


Figure 25 200m Dwelling Exclusion Zone

7.6.7 Shadow Flicker Assessment

The path of the sun around the wind turbine can be modelled and the 'shadow flicker' from the blades can be understood and quantified. If there are any significant effects the site layout is adjusted to reduce the effect. Typically if the noise exclusion zone is accounted for as outlined previously this would normally provide a sufficient boundary that shadow flicker would pose a problem.

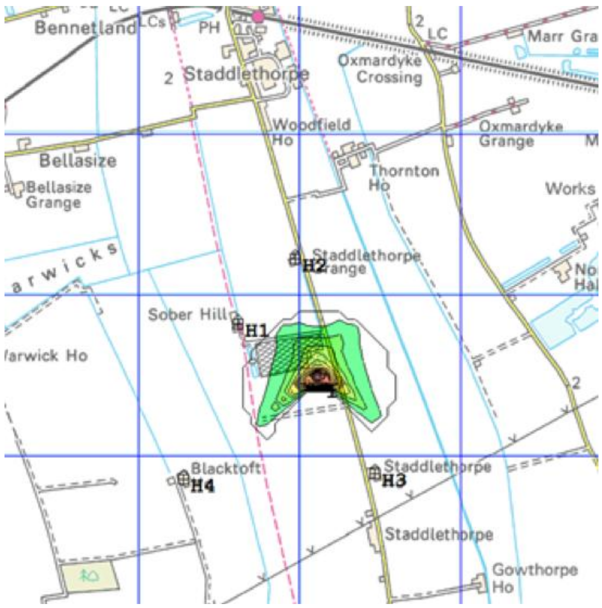


Figure 26 Example of a Shadow Flicker Map

7.6.8 Initial Planning Checks / Consultation

All of the ecological and landscape designations around the site are checked and investigated for the presence of birds, bats or other species which could be affected by a wind turbine development. Additionally Special Protection Areas and Special Areas of Conservation within 20 km of the site are also noted.

7.6.9 Initial Communication and Aviation Consultations

In conjunction with the planning checks, the necessary initial aviation checks for all radar, MOD low flying areas and nearby airports and aerodromes are made.

Contact will be made with the communications links bodies to establish the presence of microwave links across the sites, and the likelihood of possible interference from a wind turbine. Mitigating steps can then be taken.

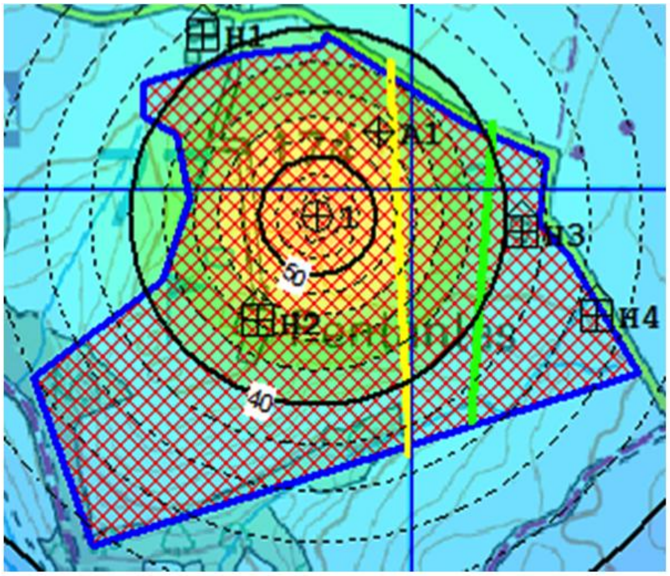


Figure 27 Example of Communications & Aviation Map

7.7 Grid Connection

The 11,000 volt network was mostly built in the 1950's and 1960's to bring electricity to rural homes, farms and communities. It was not designed to connect the wind turbines (up to 250KW) that are appearing today (typical farm maximum demand is around a tenth of this figure).The cost of the connection will depend on the location of the applicant and the amount of line upgrade that may be required. If the location is at the extremity of the 11,000 volt network the cost will be greater than a location closer to the central main line. This makes it difficult to provide indicative costs that can be used as a guide by prospective applicants.

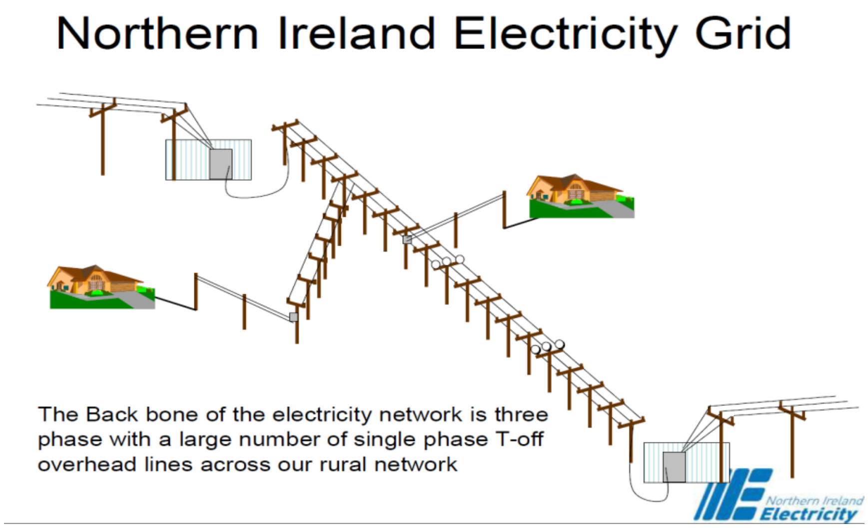


Figure 28 Northern Ireland Electricity Grid

There are two grid connection standards which ensure the safety of people and equipment. These are termed 'G83' and 'G59'. Both standards require synchronisation with the grid voltage cycle and loss of main detection with automatic disconnection within 0.5 seconds. The G83 standard is the simpler of the two and allows for 'type approval' of equipment usually avoiding an on-site safety check. This reduces costs but only allows for an output of up to 16Amps per phase, making it unsuitable for larger wind turbines.

The grid connection standard for wind turbines in the 50 – 500kW range is termed 'G59'. Equipment suitable to perform the functions required in the G59 standard is available for connection at both 400V and 11kV. However, the connection process is slightly more complicated in that the District Network Operator (DNO) will need to approve the connection design, G59 settings and earthing arrangements as well as perform an on-site 'witness test' to ensure that the standards have been met.

When a wind turbine operates whilst connected to the electricity distribution system this is classified as 'Distributed Generation' or sometimes called 'Embedded Generation'. The vast majority of 50 – 500kW wind turbines operate in this way and therefore require a suitable grid connection design.

7.7.1 Connection requirements

The electricity supply grid was designed before embedded generation became commonplace. The pylons and wires of the ‘Transmission System carry electricity from the large electricity generators around the country at 275,000V (275kV) or 400,000V (400kV).

The Distribution Network Operator (DNO) extracts electricity from this extra high voltage network and distributes it to consumers via a series of transformers and its own distribution wiring (33kV and 11kV). Domestic and small industrial users typically take their electricity as a 230V single phase supply or a 400V three-phase supply.

Wind turbines in the 50 – 500kW range will require a 3-phase 11kV supply. The connection voltage will almost certainly be 400V at the lower end of this range but depending upon the site situation an 11kV connection may be necessary.
The main requirement is that there are 11kV distribution lines in the general area. Connection to higher voltage parts of the network (33kV+) is likely to be too expensive for 50 – 500kW wind turbines.

7.7.2 Distribution Network Operator (DNO) Applications

It is the DNO who would be responsible for connecting a wind turbine to the electricity grid rather than the electricity supply company. Northern Ireland Electricity (NIE) is the DNO for Northern Ireland. When a proposal to install embedded generation, such as a wind turbine, is put forward the DNO is legally obliged to provide a connection to the grid. However, the 'sting in the tail' is that this is not free and the DNO is entitled to charge for the costs involved in providing and maintaining the connection.

7.7.3 Connection Costs

Depending upon the required modifications to the DNO's network (often referred to as 'upgrade' or 'reinforcement') the DNO charges can be substantial. It is possible in sparsely populated areas that the local network will not be sufficiently 'strong' to accept the power from the proposed project. This is often a concern given that wind turbines are usually installed in rural locations. The level of DNO costs often seem surprisingly high to applicants not familiar with grid connection issues. For turbines in the size range 50 – 500kW, projected connection costs vary from less than £10,000 to over £500,000. This obviously has a huge bearing on the financial viability of any proposed project and makes it vital to pick sensible options early in the project.

These factors can often lead to something of a 'chicken and egg' situation. The DNO is naturally unable to provide a reliable quotation since the turbine has not been selected and the electrical design is not complete – but the client cannot choose the best option without gauging the likely connection costs. For example it would be vital to know early on if the existing cabling and site transformer were able to accept generation up to 120kW without modification whilst over 200kW would require several miles of the 11kV network to be re-strung

7.7.4 Network Assessment

NIE have issued the following chart which gives an indication of the typical connection that could be accommodated on the 11kV network so that they can maintain the voltage levels within their statutory limits. It is apparent from the chart that the further away from the 33/11kV substation you are located the more likely that you will be offered a connection at huge expense. For example from the chart we can see that at 2km from the substation the network can accommodate 500kW without upgrade, however at 10km from the substation this drops to 100kW. Additionally if for instance someone else has been offered a grid connection on the same line you could find that you may have to pay for expensive upgrades even if you are closer to the substation.

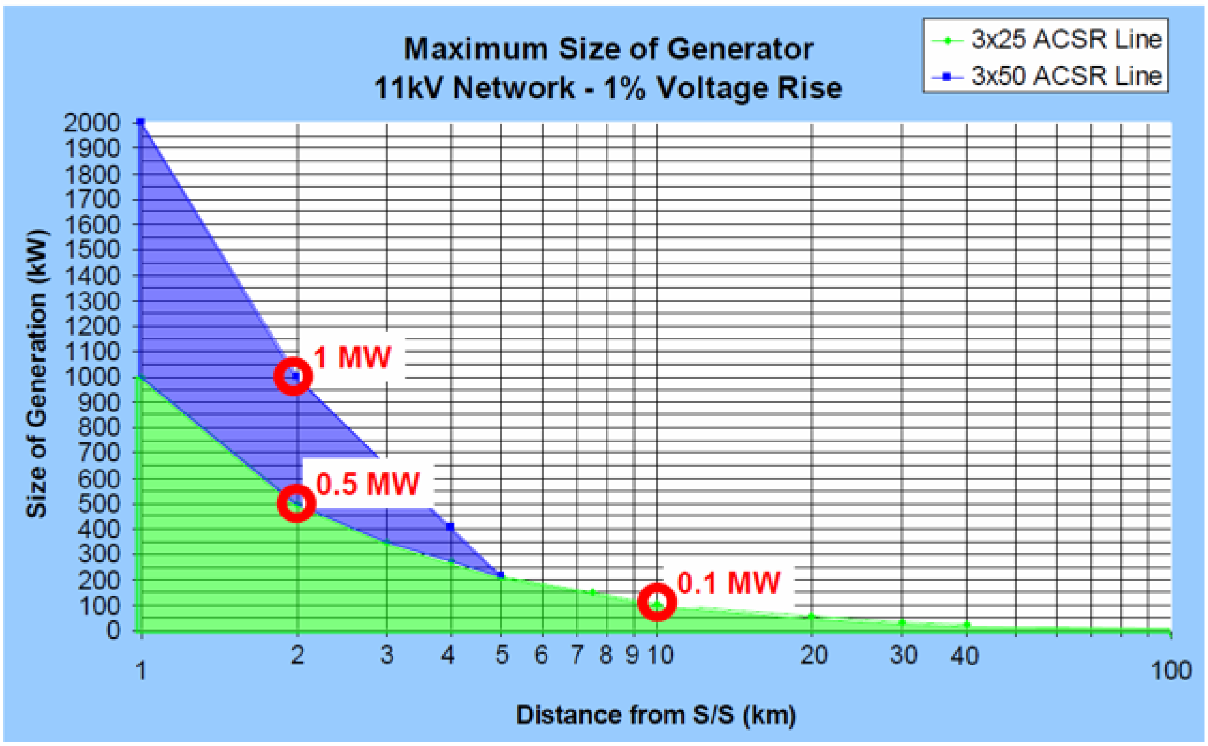


Figure 29 Maximum size of generator that can be connected to the 11kv network which results in a 1% voltage rise *v* distance from substation in km (Source: NIE)

Using geographic maps of the high voltage network, system schematics, other system data and turbine generator characteristics, it is possible to provide an initial indication of any anticipated network limitations (e.g. voltage rise). NIE must keep the voltage rise on their network within certain operating parameters and so they will not allow equipment to connect to the network that would cause a voltage rise above 1%. As the distance from the substation increases the greater is the impact of generating equipment on voltage rise. From the diagram it can be seen that at 2km from the substation a 500kW generator can connect without causing the voltage rise to breach the 1% statutory limit (up to 1MW depending on line rating), whereas at a distance of 10km from the substation connecting a 100kW generator will have the same effect. This means that if a larger generator wanted to connect to the grid at this point significant upgrade of the grid infrastructure would have to be undertaken at the (wind) developers expense. We have therefore based the assessment for the potential for wind development on the proximity to the Draperstown 11/33kV substation (as indicated on the map as a black dot) as development costs increase significantly as distance from the substation increases. Part of the 33kV network is also shown on the map (black line).

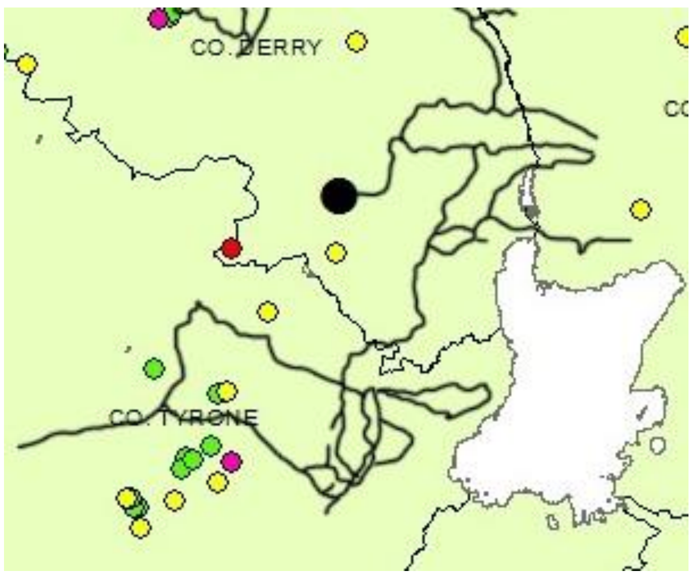


Figure 30 Draperstown Substation and 33kV Network

A full 'Network Assessment' can identify the most promising grid connection point, location of the relevant primary substation(s) and will also provide a view on the expected costs and difficulty of connecting a range of different types of turbines. Given that grid connection costs are often the second largest cost category after the purchase of the turbine itself, they can significantly affect project financial performance.

For the purposes of our evaluation we have therefore looked at the potential for development within a 5km 'buffer' zone centred on the substation location close to the town centre.

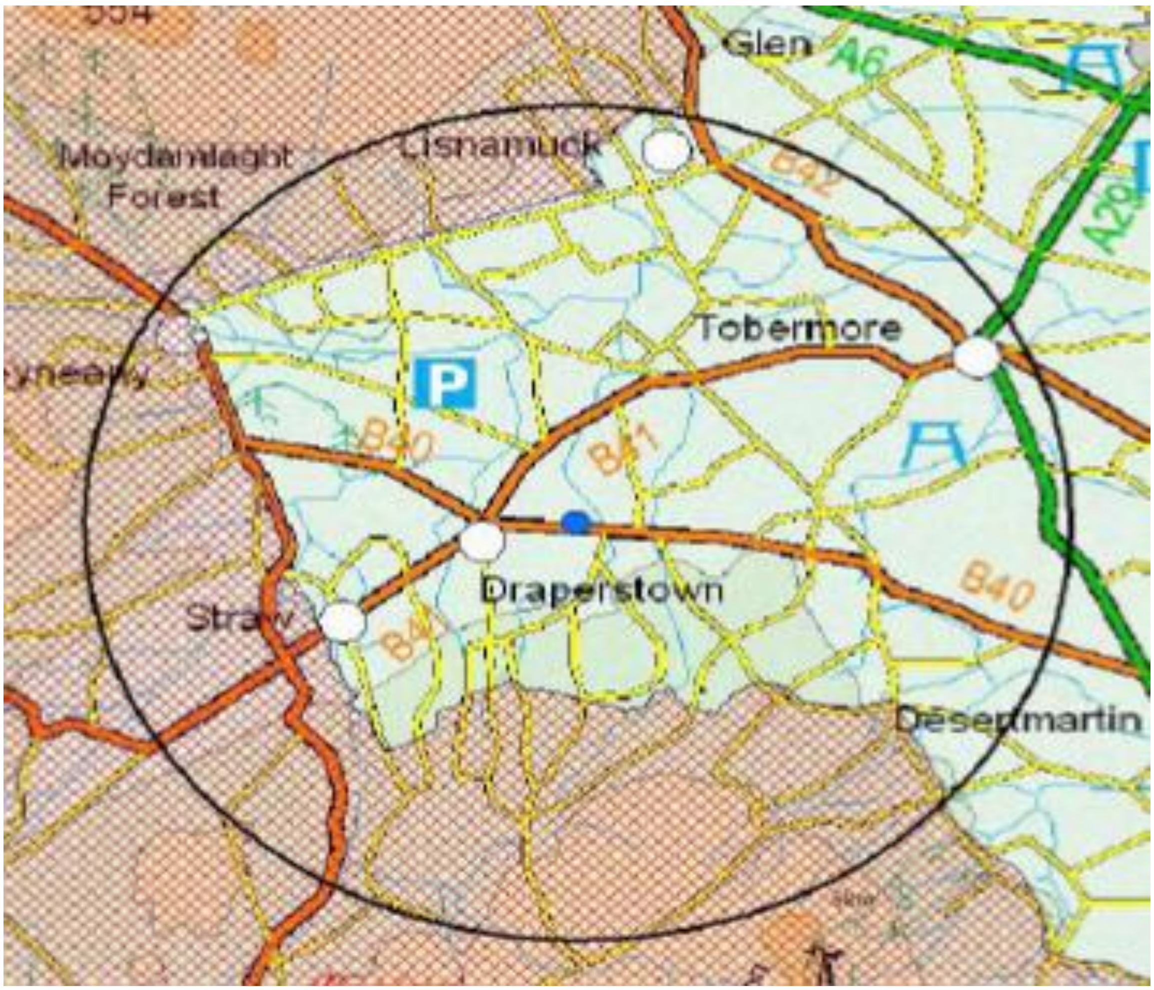


Figure 31 NIE 33/11kV Substation (Blue Dot)

7.7.5 Energy Production Estimate

Income from Wind is usually in the form of NIROC's and electricity sales. The Renewables Obligation is the main support scheme for renewable electricity projects in the UK. It places an obligation on UK suppliers of electricity to source an increasing proportion of their electricity from renewable sources. A Renewables Obligation Certificate (ROC) is a green certificate issued to an accredited generator for eligible renewable electricity generated within the United Kingdom and supplied to customers within the United Kingdom by a licensed electricity supplier. One ROC is issued for each megawatt hour (MWh) of eligible renewable output generated. The Renewables Obligation (Northern Ireland) Order came into effect in April 2005 and the Northern Ireland Renewables Obligation (NIRO) was introduced by the Department for Enterprise, Trade and Investment (DETI).

Onshore wind attracts 4 ROCs up to 250kW and 1 ROC for sites that are over 250kW capacity. The price of ROCs vary but an average value achieved under a suitable trading agreement would be £45 per ROC (£45 per MWh generated). The electricity exported would usually sell at either a fixed rate based on the season and the time of day (STOD Tariff), or under an agreed rate under the price of electricity trading in the SMP (usually 95% of SMP): an average cost for this is 6.9p/kWh.

Suitable sites are those with wind speeds in excess of 7m/s. The following table gives the average amount of wind energy generated and potential income for a 225kW turbine at different wind speeds.

Average Annual Wind Speed	**7m/s**	**6m/s**	**5m/s**
Annual Energy Production AES (kWh)	600,000	400,000	250,000
Income from ROCs	£108,000	£72,000	£45,000
Income from export	£41,400	£27,600	£17,250
Total Income	**£149,400**	**£99,600**	**£62,250**

Table 7 Average income from annual wind speeds

These figures are given as a guideline only however, it is evident that a reduction in wind speed has a huge impact on the productivity of the turbine. In fact a study conducted on the amount of ROCs claimed by some small single turbine sites within Northern Ireland revealed a very telling tale. The ROC claims made were much lower than anticipated and so revealed that the amount of electricity that these sites were generating was lower than expected. Some sites were operating at a Wind Capacity Factor of under 12%. (ie. For a 225kW turbine operating for 8760 hrs per year at 12% capacity factor would produce 236,520 kWh per year). This may be due to incorrect siting of the turbine, low wind speeds or mechanical failure. In comparison a large wind turbine situated at a good site in Northern Ireland could expect to operate at a capacity factor in excess of 35%.

7.7.6 Summary

There are a number of factors that make wind development within the Draperstown region a challenging task. However by performing in depth site-level analysis of wind speed, grid connection, and planning restrictions (eg. Noise propogation) there will be opportunities identified within the region for future single turbine wind development. This report highlightes the need for proper and detailed analysis of all the contributing factors before embarking on wind development to ensure adequate capacity factors that will provide appropriate return on investment.

7.7.7 Wind Turbine SWOT Analysis

Strengths	• Area close to substation has sufficient wind speeds to support potential wind turbine location with careful selection of the site
Weaknesses	• Best opportunities appear to lie in the landscapes on the southern edge of the valley which may be too far from suitable grid access.

	• Locations close to businesses (with potential exception of Sperrin Metals) are unlikely to prove suitable for wind development
Opportunities	• There are sufficient opportunities to explore potential sites within the LCA. The next step would be a full wind feasibility study to include site visits.
Threats	• There will be competition for grid connection which is usually on a ‘first through planning’ basis

8. Other Longer Term Options

This part of the study examines the longer term renewable energy options for the area. These options are longer term as the technology is either not fully proven or the finance aspect of the technology is restrictive and therefore are unlikely to contribute to the areas Carbon Positive targets for 2020. Nevertheless, with consistent enhancements in R&D, innovation and a changing regulatory environment in renewable energy in Northern Ireland, these longer term solutions are worthy of a brief review in this study.

8.1 Advanced Thermal Treatments

The term Advanced Thermal Treatment (ATT) Technologies is mainly used to describe the processes of **Pyrolysis** and/or **Gasification**, but which exclude incineration, in order to recover energy from waste materials.

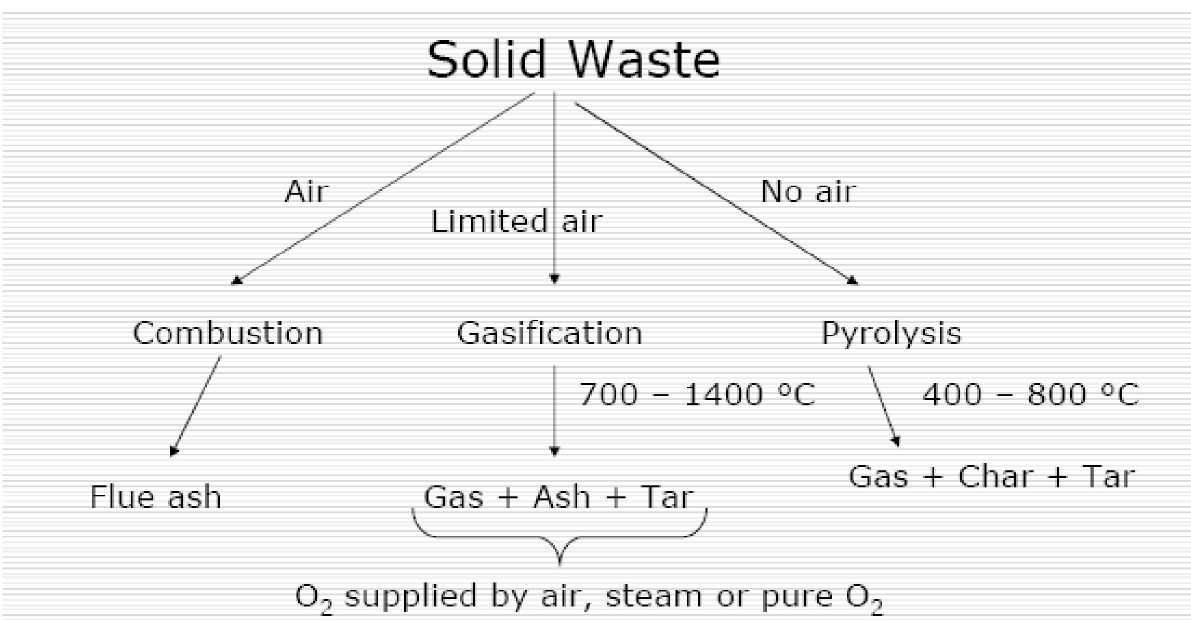


Figure 32 Advanced Thermal Treatments

Pyrolysis is defined as the thermal degradation of a substance in the absence of oxygen (Enviros Consulting, 2007). Temperatures of between 300℃ and 850℃ are typically used and three products formed: a solid residue (sometimes known as char) and a synthetic gas (syngas) and a tar. The char consists of non-combustible materials, such as metals, and carbon. The syngas is a mixture of gases including carbon monoxide, hydrogen, methane and a broad range of aromatic and aliphatic hydrocarbons. A portion of these hydrocarbons can be condensed to produce oils, waxes and tar, which themselves can be used as fuels or alternatively combusted to produce heat.

Gasification differs from pyrolysis in that small amounts of oxygen are present in the reaction vessel, meaning that partial oxidation of the substrate occurs. Gasification typically utilises higher temperatures than pyrolysis, and the majority of products are gaseous. In continuous processes, exclusion of air is a major technical challenge, the result of which is that most industrial ATT processes are gasification.

Pyrolysis and Gasification are not new processes, they have been used since prehistoric times for preparing charcoal and coke, and were the way in which town gas, contained in early municipal gas distribution networks, was prepared from coal.

ATT holds several advantages over conventional direct combustion of the substrate:

- Easier control
- Lower air/fuel ratio required
- Simple burner construction
- No particle emission
- Less gaseous emissions
- Less fouling

Furthermore, the temperature which can be achieved via the combustion of the gaseous ATT product is typically higher than that of the unprocessed material. This higher temperature means that they can be used in internal combustion engines and used to efficiently produce electricity.

Gasification differs from pyrolysis in that oxygen in the form of air, steam or pure oxygen is reacted at high temperature with the available carbon in the waste to produce a gas, ash and tar. Partial combustion occurs to produce heat and the reaction proceeds exothermically to produce a low to medium calorific value fuel gas. The operating temperatures are relatively high compared to pyrolysis, at 800 – 1100^{O}C with air gasification and 1000 – 1400^{O}C with oxygen. Calorific values of the product gas are low for air gasification approximately 4-6MJ/m^3 and about 10-15 MJ/m^3 for oxygen gasification. The resulting gas mixture is called syngas (from synthesis gas or synthetic gas) or producer gas and is itself a fuel.
The advantage of gasification is that using the syngas is potentially more efficient than direct combustion of the original fuel because it can be combusted at higher temperatures or even in fuel cells, so that the thermodynamic upper limit to the efficiency defined by Carnot's rule is higher or not applicable. Syngas may be burned directly in gas engines, used to produce methanol and hydrogen, or converted via the Fischer-Tropsch process into synthetic fuel. Gasification can also begin with material which would otherwise have been disposed of such as biodegradable waste. In addition, the high-temperature process refines out corrosive ash elements such as chloride and potassium, allowing clean gas production from otherwise problematic fuels. Gasification of fossil fuels is currently widely used on industrial scales to generate electricity.

Pyrolysis is a thermochemical decomposition of organic material at elevated temperatures without the participation of oxygen. It involves the simultaneous change of chemical composition and physical phase, and is irreversible.

Fast pyrolysis is a thermal decomposition process that occurs at moderate temperatures with a high heat transfer rate to the biomass particles and a short hot vapour residence time in the reaction zone. Several reactor configurations have been shown to assure this condition and to achieve yields of liquid product as high as 75% based on the starting dry biomass weight. They include bubbling fluid beds, circulating and transported beds, cyclonic reactors and ablative reactors.

Fast pyrolysis of biomass produces a liquid product, pyrolysis oil or bio-oil that can be readily stored and transported. Pyrolysis oil is a renewable liquid fuel and can also be used for production of chemicals. Fast pyrolysis has now achieved a commercial success for production of chemicals and is being actively developed for producing liquid fuels. Pyrolysis oil has been successfully tested in engines, turbines and boilers, and been upgraded to high quality hydrocarbon fuels although at a presently unacceptable energetic and financial cost.

8.2 Incineration

The modern incinerator is an efficient combustion system with sophisticated gas clean-up which produces energy and reduces the waste/ feed stock to an inert residue with minimum pollution. Incineration plants may be classified, on a variety of criteria (capacity, feedstock, type of system).

8.2.1 Mass burn incineration

At a Municipal solid waste (MSW) combustion facility, MSW is unloaded from collection trucks and placed in a trash storage bunker. An overhead crane is used to sort the waste and then lift it into a combustion chamber to be burned. The heat released from burning is used to convert water to steam. The steam is then sent to a turbine generator to produce electricity. The remaining ash is collected and taken to a landfill. Particulates are captured by a high-efficiency baghouse (a filtering system). As the gas stream travels through these filters, more than 99 percent of particulate matter is removed. Captured fly ash particles fall into hoppers (funnel-shaped receptacles) and are transported by an enclosed conveyor system to the ash discharger where they are wetted to prevent dust and mixed with the bottom ash from the grate. The ash residue is then conveyed to an enclosed building where it is loaded into covered, leak-proof trucks and taken to a landfill designed to protect against groundwater contamination. Ash residue from the furnace can be processed for removal of recyclable scrap metals. Figure 33 illustrates how the energy recovery process works.(EPA USA website)

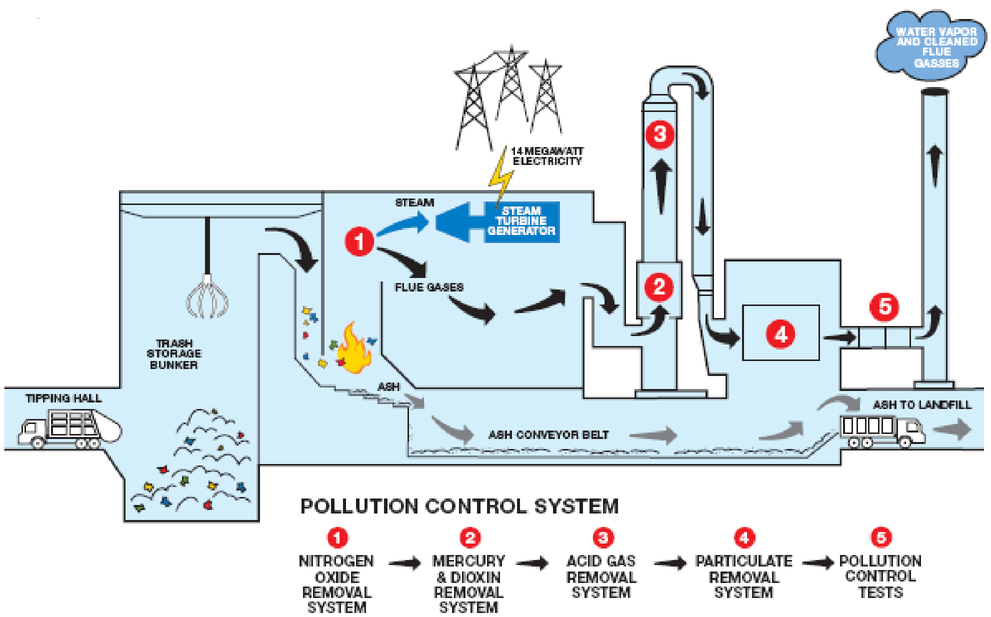


Figure 33 Example of Mass burn Incineration

8.3 Solar

There are two main types of active solar energy usage which could be part of a community scale energy supply strategy:

- Solar thermal energy, whereby large solar collector arrays are used to transform light into heat and supply it through a water-based district heating system, possibly with seasonal storage.

- Solar photovoltaic energy, whereby large arrays of solar PV panels are used to generate electricity which is fed into and distributed via an electrical network.

Solar photovoltaic energy is limited by the space available to host solar arrays and associated orientations and inclinations for the panels. Demand is not a factor as all solar power produced can in theory be exported to the grid.

8.4 Hydro Energy

Hydro-electricity is produced by using the power of water under pressure to turn the turbines of generating sets in power stations. There are two main types of small hydro-schemes operating in Ireland; low head and high head schemes. Low head run of the river schemes and are located in lowland areas, abstracting water from rivers through the use of weirs with diversion of river flow to a headrace and from there to a turbine house. Water is returned to the river downstream of the turbine through a tailrace. The power produced in a hydro scheme varies directly with the head (the vertical distance between the headrace and tailrace level) and water flow. Generally the head is less than 5 m in low head schemes and the schemes have little impoundment or provision for storing water. Because the head is low, compared to that at high head schemes, the volume of water used per unit of power is high. A number of old — low head schemes have been redeveloped with the introduction of modern more efficient turbines with higher generating capacities. Modern turbines can operate efficiently with flows as low as one quarter or less of their full load design flow.

High head schemes can be divided into run of the river schemes and impoundment schemes. Both high head run of the river and impoundment schemes utilise upland catchments where sufficient head is available. Water is drawn through a pipeline/tunnel from a high level to a powerhouse. Run of river schemes have little or no storage and exploit the natural river flow which is piped to a power house sometimes distanced kilometers downstream. The schemes usually incorporate a pool area above a natural or manmade weir across the river and a fully submerged intake arrangement which feeds the pipe which is positioned along the bank of the pool. Some high head schemes incorporate storage utilising upland lakes whereby enhanced storage in the lake is used to augment the flow available for abstraction.

9. Capital costs

Capital costs of each of the identified renewable energy technologies are detailed below. Cost information was sourced from suppliers of the technologies throughout the UK (where available) and more widely in Europe. These costs are budget costs and do not include additional costs for civil work.

9.1 Budget costs for 500kW AD system

Build and development Costs	£
Contract Price	2,455,000
Civils Fees	144,000
Grid Connection Offer	250,000
Silage Clamp	200,000
Professional Fees	90,000
Planning Development Costs	60,000
Total	**3,199,000**

Table 8 Development Costs for 500kW AD system

Direct Cost	Quantity (tonnes)	Cost / Tonne £	Cost/ Annum £
Silage	11,720	27.50	322,300
Slurry	3,250	1.58	5,122
Water	200	0.53	105
Total Direct Costs			**327,527**

Table 9 Direct Costs

Annual Operational Costs	£
Farmer Salary	20,000
Management Fees	30,000
CHP and Other Maintenance	79,000
Biological Support	8,000
Insurances	24,000
Site Lease	10,000
Other Miscellaneous Costs	19,000
Total Operational Costs	**190,000**

Table 10 Annual Costs

Revenue Lines	Quantity	Price / Unit £	Power purchase agreement	Revenue £
Electricity Sales	3,646	52.53	94%	180,027
Capacity Payments	3,646	8.05	94%	27,579
ROCs	15,680	47.28	94%	696,879
Levy exemption certificates	3,920	5.10	80%	15,980
Heat Sales	1,576	25.00	-	41,415
Annual Revenue				**961,880**

Table 11 Revenues

9.2 Budget costs for 3200kW biomass boiler system

There are a number of assumptions made in the costing;

1. The system is 80%efficient
2. 4no. 800kW boilers run with one reserve boiler for maintenance
3. 1kW is sold at the budget £0.028, (2.8p)
4. The wood chip is of a maximum 25% moisture
5. The system operates 24hours per day all year round
6. The system operates at full capacity for 4380hours per year and 50% capacity for the remaining time.

7. The costs don't include the home heat exchanger, following discussions with suppliers this is purchased by the home owners in a similar manner to a domestic boiler.

Item	Costs
Boiler cost	£141,250
Capital costs	£543,270
Boiler feed cost	£52,000
Annual running costs	£208,000
Income from heat sales	£588,672

Table 12 Biomass Boiler costs Costs

9.3 Budget costs for wood chip pyrolysis unit with 1MW CHP

There are a number of assumptions made in the costing;

1. The system is 80%efficient
2. 1kW is sold at the budget £0.028, (2.8p)
3. The wood chip is of a maximum 25% moisture
4. The system operates 24hours per day all year round
5. The system operates at full capacity for 4380hours per year and 50% capacity for the remaining time.
6. The costs do not include a home heat exchanger.
7. This does not include the cost of grid connection.

Items	Costs
Capital costs	£3,900,000
Annual running costs	£258,000
Income from heat sales	£551,880
Income Electricity sales	£341,640
Income from ROCs	£525,600

Table 13 Wood Chip Pyrolysis Costs

Please note that the ROCs for gasification/pyrolysis systems have been projected to drop from 2015 to 1.9 and 1.8 in 2016.

9.4 Budget Costs for District heating System

The following costs are based on the assumption that there was no prior heat network infrastructure in the area, with all dwellings fitted with individual heating systems.

Dwelling type	Infrastructure cost	Branch cost	Meter and maintenance cost	Total cost
Small Terrace	£3,015	£2,177	£2,300	£7,492
Medium/ large terrace	£3,015	£2,556	£2,300	£7,871
Semi detached (town)	£3,391	£2,584	£2,300	£8,275
Semi detached (rural)	£5,424	£3,139	£2,300	£10,863
Converted flat	£1-2,000	£852	£2,300	£4/5,157
Purpose built flat	£2,127	£0	£2,300	£4,427

Table 14 Poyry report – The Potential & Costs for District Heating

It is assumed that the heat will service a third of the properties in the area, approximately 771. There are 500 homes in town and 271 in rural areas, again the assumption is made that there is a 50% 50% split of terrace to semi-detached homes in town and all out of town are semidetached.

Item	Cost
250 terrace homes	£1,873,000
250 semi detached town homes	£2,068,750
271 semi detached rural homes	£2,943,873
Total	£6,885,623

Table 15 Capital Costs

The analysis above is based on average district heating costs figures taken from literature. In reality, costs will vary widely depending on the design and layout of the district heating network, the heat demand density along the network route, operational factors (pressure, temperature, storage, etc.) and management. This is illustrated by the results obtained from the high-level feasibility study of two sample projects presented by Delap and Waller EcoCo which are shown below.

- one examines a simple network with a limited number of connections to high heat users in the town centre (hotels, nursing home, etc.), with a cost of 1.7 cents per unit of heat circulated;
- one a small network supplying a housing estate with a relatively low heat density and large connection cost resulting in a cost of 6.4 cents per unit of heat circulated.

9.4.1 Example 1: Town-centre district heating scheme (4GW/yr)

District heating (DH) network servicing 7 commercial and public buildings, 40 social housing units and a new mixed used development, with a total annual heat demand of 3.9GWhr.

The boiler house is to be placed on land owned by the town council and integrated as part of a new public building project. The installation of the DH network requires laying out of pipework under existing roads and pathways and retrofitting of heat transfer stations into existing buildings.

	Costs
Lifetime (years)	20
Capital cost (£):	£388,462
Annual running costs (£/yr):	£19,958
Cost of heat distribution per unit (£/kWh):	£0.02

Table 16 Capital Costs of District Heating Scheme (Example 1)

The cost of owning and operating the DH scheme adds a significant burden on the viability of large-scale renewable heating projects relying on district heating to access customers. Where waste heat is available from industrial processes or as a by-product of a CHP system (from AD CHP for example), the lower cost of the heat input can deliver a positive return on investment.

The cost of installing district heating depends largely on the density of services (electricity, water, telecom,. etc.) underground. A high instance of services relocation requirement can more than double the capital cost of district heating.

9.4.2 Example 2: Social housing district heating scheme (300 MW/yr)

District heating network servicing 27 social housing units, retrofitted to replace solid fuel heating in relatively recent semi-detached houses with relatively well insulated fabric. The boiler house is to be placed on land owned by the town council and integrated as part of the retrofitting project. The installation of the DH network requires laying out of pipework under existing roads and pathways and retrofitting of heat transfer stations into existing wet heating systems. Total heat demand is estimated at 300 MW per year.

	Costs
Lifetime (years)	20
Capital cost (£):	£118,462
Annual running costs (£/yr)	£5,665
Cost of heat distribution per unit (£/kWh):	£0.06

Table 17 Capital Costs

The cost of owning and operating the DH scheme is very high due to relatively large capital costs and low heat intensity of the estate. This renders the renewable heat based DH scheme uneconomical, unless waste heat or CHP is used. The social housing provider would also have to invest significantly into the supply and installation of the DH system, which can then be operated by a specialist operator.

9.5 Budget Costs for District biogas network

The concept of using gas distribution networks for the distribution of renewable gas to consumers is gathering momentum in Europe. The transmission and distribution of biogas from production sites (AD plants) to potential gas users is a particularly interesting alternative to onsite heat or combined heat and power generation, since the demand for heat on site is often limited and transfer through district heating is expensive. Gas distribution networks are typically significantly cheaper and easier to install than district heating networks. Biogas is also a versatile renewable fuel which can be used for heat production, power generation or as a transport fuel.

Renewable gas can be produced by anaerobic digestion or gasification of wood. Biogas from anaerobic digestion has high methane content and can be made compatible with standard gas appliances. In areas where the natural gas grid is already in place, biogas can be injected into the gas grid, after having been upgraded and compressed. In some cases, biogas can be injected into the natural gas network at up to 8% substitution without upgrading.

In areas where the natural gas network is not present, such as in this study area, developing a localised network for the distribution of biogas is increasingly seen as a potential alternative to district heating. The different possible components of a small-scale biogas network (often referred to as micro-network) include:

- Producers and suppliers of biogas (anaerobic digestion (AD) plant(s));
- Gas treatment plant (gas cleaning, methane content upgrading, compression);
- Multiple biogas users (residential, commercial, industrial, transport);
- A distribution network at low pressure, typically made of polyethylene pipes;
- Biogas storage capacity;
- Where feasible, a connection to the gas grid.

Achieving autonomy with a micro-network would require a very large storage capacity to balance seasonal variations in supply and demand, requiring expensive and complex technology (liquefied natural gas). Connecting to the natural gas network would provide several advantages:

- Absorb excess biogas production in periods of low demand (summer);
- Be a back-up source of biogas in periods of peak demand;
- Allow better control and regulation of the quality of gas supplied to end-users.

The need to upgrade raw biogas depends on the ability of consumer's appliances to use varying quality of biogas. In the context of a micro network distributing to residential users, heating and cooking appliances currently on the market would have a relatively low level of tolerance. Bigger appliances such as commercial boilers or CHP units can use raw biogas with a basic treatment (desulphurisation). Upgrading the biogas to a level of quality comparable to that of the natural gas includes extracting CO_2 from the raw biogas to increase its methane content to over 95%. It is an expensive process which nevertheless increases consumer acceptance and reduces transport and storage capacity (higher energy density of the gas). Continued research and development into new small-scale combustion technologies should reduce the need for consistency in gas quality and allow the distribution of less enriched biomethane, at cheaper cost to the producer and consumer.

Biogas has also a significant potential as a transport fuel, notably because its lifecycle energy performance is much better than first generation liquid biofuel such as methanol. As an agricultural fuel, the land requirement of biogas is also much lower. According to UCC (Brown, 2010), the land requirement of biogas from grass is 3 times less than oil seed rape biodiesel or methanol from sugar beet or wheat. If biogas is produced from animal by-products, industrial or municipal organic waste, the production of biogas effectively doesn't require substitution of land from food production to energy.

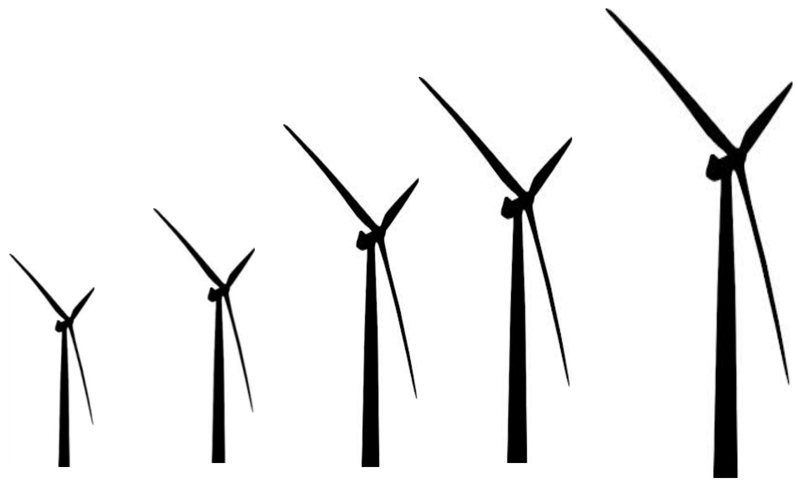
If it assumed that the micro network supplies a group of homes and schools local to the Workspace business units at the edge of Draperstown, approximately 3km from the Anaerobic Digestor production site and that all end users have micro CHP units, it is estimated that the cost of the pipeline would be £95-£105 per meter including trenching.

Town Grid	£
Transmission from Production	370,320
Connection costs (40 Domestic)	52,000
Connection costs (4 Large premises schools)	40,000
Connection costs (20 small business)	26,000
Total Cost	488,320

Table 18 Capital costs for gas distribution grid

9.6 Wind turbines

A new 225 – 250 kW wind turbine costs approx. £400,000. The cost of taking a site from concept to completion on a turbine of this size is circa £550,000. The cost of this is often the barrier to entry for individual land owners and farmers. Connection to the grid and sales of excess electricity, with a 225 – 250 kW turbine will generate revenues of approx. £100,000 per annum if situated on a suitable site. The payback is approx. 4 years, making a wind turbine an attractive financial investments to businesses / farms wanting to reduce the cost of energy to their organisation. Maintenance costs can range from £5,000- 10,000 per annum for a turbine of this size. If a turbine is well maintained it can have a life span of 20 years - however it must be noted that at some point the gearboxes, inverters and batteries will need to be replaced. For large scale onshore wind development (wind farms with 2MW turbines) an indicative cost is approximately £1m/MW installed. The figure below shows an indication of typical installed cost (Turbine & Civil works) of a range of different sized turbines. As stated the grid connection cost can be highly variable depending on Grid Access.



Turbine Size (kW)	10kW	50kW	100kW	225kW	750kW
Total Costs (£)	**£45,000**	**£180,000**	**£350,000**	**£550,000**	**£1,200,000**
Power Output (kWh/annum)	35,000	150,000	300,000	500,000	1,400,000
ROC Income	£6,300	£27,000	£54,000	£90,000	£63,000
Electricity Income	£875	£3,750	£7,500	£12,500	£35,000
Electricity Savings	£2,450	£10,500	£21,000	£35,000	£98,000
Turnover (£/annum)	**£9,625**	**£41,250**	**£82,500**	**£137,500**	**£196,000**
Net Profit (£/annum)	£8,181	£35,063	£70,125	£116,875	£166,600
Simple Payback (years)	5.5	5.1	5.0	4.7	7.2
Net profit over 20 yrs	**£118,625**	**£521,250**	**£1,052,500**	**£1,787,500**	**£2,132,000**

Figure 34 Typical Costs of installing wind turbines showing growing economies of scale. The revenue calculations for the turbines are based on a combination of NIROC's and electricity savings from the substitution of imported power. Wind turbines with an installed capacity of under 250kW currently receive 4 NIROC's. For this analysis an average ROC value of £0.045/kWh was assumed. The electricity savings from imported power have been based on a current electricity tariff of £0.14/kWh with 50% of the power used internally and the remaining 50% exported at £0.05/kWh.

10. Conclusion

10.1 The Opportunity

The main objectives of this renewable energy feasibility study are:

- To undertake baseline analysis on the total energy use for the Parish of Ballinascreen (Draperstown, Co. Derry) and
- To identify sustainable energy initiatives, including energy efficiency measures and renewable energy solutions that will help towards the Workspace commitment to become a carbon positive region by 2020.

The project concept was developed by a consortium of nine businesses in the Draperstown area and led by Workspace, a social enterprise organisation with a remit that its' business ventures will have a positive impact on the local community. To that end, the overall community benefit from any recommended sustainable energy scheme has been considered in this study. The baseline energy study concentrated on domestic and commercial / industrial load with 81.4GWhrs of electricity used within households in the region (extrapolated from data collected from within the schools) and 4.388 GWhrs of electricity used by the nine companies involved in this innovation voucher project. Even without taking all of the additional businesses in the Parish in to account, there was sufficient evidence to determine that the base load electricity usage is significant enough to consider both an energy minimisation campaign and also to further consider a range of renewable energy options for the area. As well as housing, the town centre is also served by a number of retail and fast food outlets, a Doctor's Surgery, Dentist, Library, Back Row Sports Centre, a Primary and Secondary school and a Fold, all contributing to the overall energy usage in the area. In addition to electricity use, the baseline survey also indicated that fuel transport costs are an issue both for the domestic and industrial representatives of the town. The options considered within this study therefore included the potential to create biogas / biofuels to provide a cheaper and more sustainable alterative to petrol and diesel for vehicles.

Having established that the base load would support a sustainable energy scheme and the appetite of the business and local community for renewable energy within the region is strong, the next step in the project was to establish whether the region has the necessary resources to develop a sustainable energy scheme on a regional / local basis.

The rural backdrop to the Parish of Ballinascreen with a predominance of agricultural land under grass (for grazing) provides ideal growing conditions for the feedstock for Anaerobic Digestion plant(s).

A preliminary wind resource assessment also identified that an area within a 5km zone around Draperstown has sufficient wind speeds to support the generation of renewable energy from wind turbine development. There are a number of planning and grid connection constraints that need to be taken into consideration when developing wind turbines / wind farm projects, particularly as parts of the region under assessment fall within the foothills of the Sperrin Mountains, in an Area of Outstanding Natural Beauty (AONB).

Given the energy use, available renewable resources and the potential community and environmental benefit from a regional sustainable energy plan, a number of potential options have been examined from the available baseline data and a review of the current available renewable energy technology.

10.2 The Options

10.2.1 Energy Efficiency

Reducing energy demand is by far the most cost-effective measure to address energy expenditure and should be taken as a priority to lay stable foundations for the implementation of the renewable energy roadmap.

An energy demand reduction target of 10% by 2020 is realistic and should initially focus on heat usage in the domestic sector with simple measures such as insulation, draught proofing, efficient heat generation and thermostatic controls. The realisation of this target would bring considerable economic and social benefits to the community, with a total domestic annual financial saving of £1,000,000 by 2020 (approximately £430 per household).

The Carbon Trust estimates that up to 20% of energy cost can be saved by implementing low cost / no cost energy management practices within businesses. Of the companies included within this survey, £1,546,637.20 is spent on energy per annum. A 20% saving equates to £309,327.44 across the nine companies.

Simple energy efficiency measures for business include[2]:

1. Conduct an energy walk around
2. Heating – do not overheat areas and prevent heat losses, adequately service equipment; do not locate heating and cooling simultaneously. Heating costs rise by about 8% for every 1^{o}C of overheating.
3. Lighting – the type of lighting, the cleanliness of the fixtures, opportunities to use LED's, timing of internal and external usage.

[2] Better Business Guide to Energy Saving, Carbon Trust

4. Switching off computers and other small power equipment when not in use
5. Monitoring and repairing compressed air leakages (a 20% - 50% ‘acceptable’ leakage is not uncommon), high efficiency motors and variable speed drives.
6. Proper management of refrigeration and chilling units – maintaining seals, door closure and maintenance of equipment.
7. Developing a thorough understanding of electricity bills

All companies involved in this Innovation Voucher project can benefit from energy efficiency and associated cost savings to a greater or lesser extent. Section 11.0 Recommendations provides the appropriate signposting to further sources of free advice and guidance for undertaking more detailed energy surveys within businesses.

10.2.2 Renewable Energy Options

The potential for combining wind energy with the following options should be explored further:

	500kW farm AD (1000kWhr)	3200kW biomass boiler (7360 kW heat)	1MW wood chip pyrolysis CHP (3.2MW heat)	4GWhr district heating system for 40 homes & 7 commercial sites	300MWhr district heating system for 27 homes	District gas distribution and micro CHP units for 40 homes, 4 large sites & 20 SMEs	250kW wind turbine
Life time	20	20	20	20	20	30	15
Capital cost £	3,199,000	736,520	3,900,000	388,462	118,462	488,320	550,000
Direct costs £	327,527						
Operating costs £	190,000	208,000	258,000	19,958	5,665		10,000
Annual revenue £	961,880	588,672	1,419,120	78,000	18,000	100,000	100,000
Annual surplus/ Deficit	444,353	380,672	1,161,120	58,042	12,335	100,000	90,000
Payback period	7.20	1.93	3.36	6.69	9.60	4.88	6.11

Table 19 Cost comparison table

10.2.2.1 Option 1: AD and District heating

Option 1 is based on a system that would utilise two 500kW farm based anaerobic digestors feeding two 4GW district heating systems, or one 8GW system.

	2X 500kW farm AD (1000kW)	2 x4GW district heating system for 40 homes & 7 commercial sites	Total cost
Life time	20	20	
Capital cost £	6,398,000	776,924	7,174,924
Direct costs £	655,054	0	655,054
Operating costs £	380,000	39,916	419,916
Annual revenue £	1,923,760	156,000	2,079,760
Annual surplus/ Deficit £	888,706	116,084	1,004,790
Payback period Yr	7.20	6.69	7.14

Table 20 Cost for option 1

Although one anaerobic digester would provide sufficient heat for the district heating system, the heat requirements are not likely to be regular and the second system is required for the peak times. Assuming that the heat requirement for the domestic sector is 67.89GW per year (based on the sum of the energy spend on oil, gas and solid fuels), this arrangement would provide 11% of the total domestic heat load for the Parish.

10.2.2.2 Option 2 Biomass boiler and District heating

Option 2 is based on a system which would utilise four 800kW biomass boilers which would feed one 4GW district heating system.

	3200kW biomass boiler	4GW district heating system for 40 homes & 7 commercial sites	Total Costs
Life time	20	20	
Capital cost £	736,520	388,462	1,124,982
Operating costs £	208,000	19,958	227,958
Annual revenue £	588,672	78,000	666,672
Annual surplus/ Deficit £	380,672	58,042	438,714
Payback period Yr	1.93	6.69	2.56

Table 21 Cost for option 2

Four Biomass boilers would provide 3.5GW of heat which is slightly less than the requirement for the district heating system. It has been assumed that a 3.5GW district heating system would cost the same as 4GW system. Assuming that the heat requirement for the domestic sector is 67.89GW per year, a 4GW arrangement would provide 5% of the total domestic heat requirement for the Parish.

10.2.2.3 Option 3 CHP and District heating

Option 3 is based on a system which would utilise one 1MW wood chip pyrolsis CHP which would feed a 4GW district heating system.

	1MW wood chip pyrolysis CHP (3.2MW heat)	4GW district heating system for 40 homes & 7 commercial sites	Total Costs
Life time	20	20	
Capital cost £	3,900,000	388,462	4,288,462
Operating costs £	258,000	19,958	277,958
Annual revenue £	1,419,120	78,000	1,497,120
Annual surplus/ Deficit £	1,161,120	58,042	1,219,162
Payback period Yr	3.36	6.69	3.52

Table 22 Cost for option 3

A 1MW CHP system would provide 5.4GW of heat which is slightly more than what is required for the district heating system. Assuming that the heat requirement for the domestic sector is 67.89GW per year, this arrangement would provide 5.9% of the total domestic heat requirement for the Parish.

10.2.2.4 Option 4 CHP and District gas distribution -on farm AD

Option 4 is based on a system which would utilise one 500kW farm based anaerobic digestor which would be connected to a district gas distribution system which would feed 40 individual domestic micro CHP units and 24 larger CHP systems in community sites and SMEs.

	500kW farm AD	District gas distribution and micro CHP units for 40 homes, 4 large sites & 20 SMEs	Total Costs
Life time	20	30	
Capital cost £	3,199,000	488,320	3,687,320
Direct costs £	327,527		327,527
Operating costs £	190,000		190,000
Annual revenue £	961,880	100,000	1,061,880
Annual surplus/ Deficit £	444,353	100,000	544,353
Payback period Yr	7.20	4.88	6.77

Table 23 Cost for option 4

A 500kW anaerobic digestor using grass as a feedstock would produce sufficient gas to feed 40 homes, 4 community sites and 20 SME’s heat and electricity requirements estimated at 3.51GW (extrapolated from the data collected and assuming the properties have improved their energy efficiency). Assuming that the total energy requirement for the domestic sector is 81.372GW per year, this arrangement would provide 4.3% of the total domestic heat requirement for the Parish.

10.2.2.5 Option 5 CHP and District gas distribution - wood chip pyrolysis

Option 5 is based on a system which would utilise one 1MW wood chip CHP, assuming 50% of the gas produced is used for the gas distribution system and the remainder is used for electricity production, which would be connected to a district gas distribution system which would feed to 40 individual domestic micro CHP units and 24 larger CHP systems in community sites and SMEs.

	1MW wood chip pyrolysis CHP	District gas distribution and micro CHP units for 40 homes, 4 large sites & 20 SMEs	Total Costs
Life time	20	30	
Capital cost £	3,900,000	488,320	4,388,320
Operating costs £	258,000		258,000
Annual revenue £	1,419,120	100,000	1,519,120
Annual surplus/ Deficit £	1,161,120	100,000	1,261,120
Payback period Yr	3.36	4.88	3.48

Table 24 Cost for option 5

A 1MW wood chip CHP with 50% gas production being used to feed 40 homes, 4 community sites and 20 SMES with heat and electricity needs estimated at 3.51GW (extrapolated from the data collected and assuming the properties have improved their energy efficiency). Assuming that the total energy requirements for the domestic sector are 81.372GW per year, this arrangement would provide 4.3% of the total domestic heat requirement for the Parish.

10.3 The Preferred Option

The two largest energy usages within the Parish are electricity for the domestic homes and fuel costs for the industry sector.

The preferred renewable energy option for the Ballinascreen Parish is a mixture of wind plus Anaerobic Digestion and Biomass Pyrolysis / Gasification feeding a District Heating System. Added value will be provided by biogas or liquid upgrade and use.

Anaerobic Digestion with associated district heating would provide an ideal solution to the regions' aspirations to generate both electricity and heat from renewable sources and as a potential source of vehicle fuel (in the longer term). The feed stocks for the digestor would ideally be a mix of resources such as silage/ farm slurry and food waste, as these are all available locally. Whilst food waste is currently being collected by a contractor on behalf of Magherafelt District Council (brown bin collections), early engagement with the contractor would identify if this waste stream could become available to an AD plant operator. The digestate from AD plant would be a source of fertiliser to local farmers reducing the need to purchase chemically produced nutrients and contributing to the carbon positive efforts by reducing transport miles and the use of non-renewable resources in production.

The biomass pryolysis/gasification system used in conjunction with the gas distribution system feeding to micro CHPs and using the liquid output from gasification after clean up as a vehicle fuel, would help to reduce the districts' reliance of fossil fuels. The feed stocks for the gasifier would include biomass which is more fibrous than that used in anaerobic digestion such as miscanthus or willow. Also longer term waste material could also be used as a feed stock for gasifier. Miscanthus and willow can be grown on relatively poor ground, using the effluent from waste waste treatment plants or liquid digestate as a source of necessary nutrients.

Upgrading the gas from both the AD and gasification process would also add significant value to the system. Syngas from gasification process requires additional upgrading in comparison to biogas produced from anaerobic digestion. The gas could then be converted for use in vehicles and also for domestic micro CHP units. Gas production is not limited to anaerobic digestion, but can also be produced by gasification or pyrolysis of plastics or black bin waste.

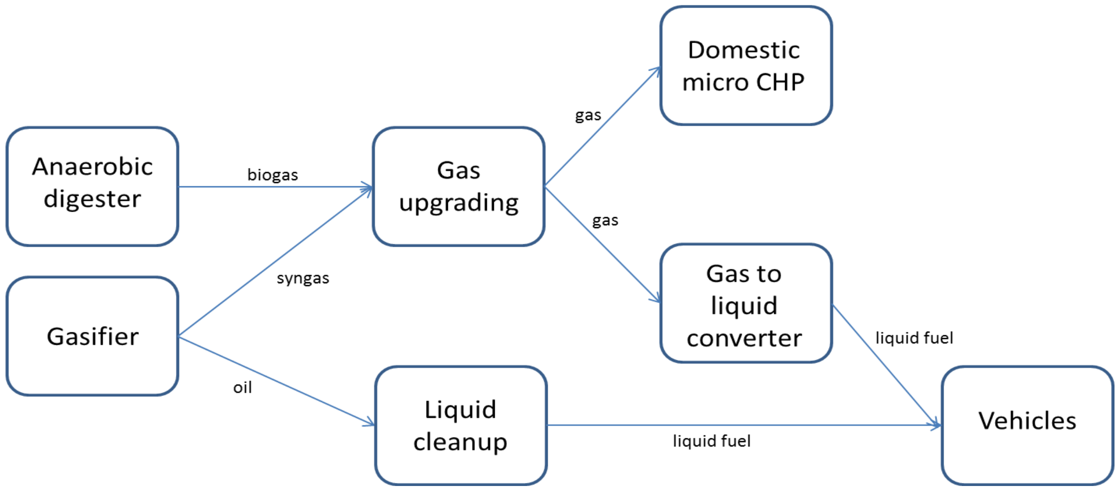


Figure 35 preferred option scenario

	500kW farm AD (1000kWhr)	**1MW wood chip pyrolysis CHP (3.2MW heat)**	**Biogas /Syngas upgrade**	**Pyrolysis oil clean up**	**District gas distribution and micro CHP units for 40 homes, 4 large sites & 20 SMEs**	**Gas to liquid convertion for vehicle fuel**	**Total Cost**
Life time	20	20	20	20	30	30	
Capital cost £	3,199,000	3,900,000	2,105,800	2,105,800	488,320	756,000	12,554,920
Direct costs £	327,527						327,527
Operating costs £	190,000	258,000	308,100	754,120		407,545	1,917,765
Annual revenue £	961,880	1,419,120	1,654,385	1,560,887	100,000	978,230	6,674,502
Annual surplus/ Deficit £	444,353	1,161,120	1,346,285	806,767	100,000	570,685	4,429,210
Payback period Yr	7.20	3.36	1.56	2.61	4.88	1.32	2.83

Table 25 Cost for preferred options

To conclude, the preferred option for the Parish of Ballinascreen is outlined in Figure 35, illustrating the use of both anaerobic digestion and gasification. Instead of producing electricity from the anaerobic biogas it is upgraded and used directly in micro CHPs or compressed to produce liquid vehicle fuels. Both are a more efficient use of the biogas than producing electricity, but the current ROCs allowance scheme favours electricity production. With the ultimate removal of the ROC's incentive the biogas and liquid upgrade is likely to provide a more cost effective solution in the longer term. The syngas produced from gasification can be upgraded and used in a district gas distribution system would also feed micro CHPs. The liquid gasification output, sometimes referred to as tar, can be cleaned up and used as vehicle fuel.

The preferred option solutions will work together symbiotically, as the digestate from anaerobic digestion can by used to help grow the biomass crops that will then be used as a feed stock for gasification. The heat produced from AD can also be used to dry the biomass to improve the efficiencies of the burn.

11. Recommendations

A robust sustainable energy strategy needs to focus on early action in energy efficiency to reduce overall energy consumption and associated costs. Only once the energy efficiency programme is complete, should the renewable energy options for the region be fully implemented.

11.1 Energy Efficiency

All of the nine companies involved in the Innovation Voucher project should consider engagement with Invest Northern Ireland to avail of free consultancy support to businesses with an overall resource and utilities spend in excess of £30,000 per annum. This consultancy is in the form of:

- An audit to identify and prioritise projects to reduce the cost of water, energy or materials and,
- Advice and support on how to implement the resource efficiency projects for example energy efficiency, equipment specifications, management systems and cleaner production.

Further information on the Consultancy Support can be found at: http://www.investni.com/index/already/maximising/managing_energy_and_waste.htm

In addition, invaluable and sector specific guidance can be found on the Carbon Trust website: http://www.carbontrust.com

A programme of awareness raising in energy efficiency in the domestic environment should also be considered and could be led by Workspace Enterprises. Advice and guidance on energy efficient measures in the domestic sector can be found at: http://www.energysavingtrust.org.uk/northernireland.

11.2 Renewable Energy Project(s)

For the most part, this report has considered a renewable energy solution for the Parish of Ballinascreen in Draperstown. However, homeowners may also wish to consider small / micro scale renewable energy projects and can potentially avail of the Renewable Heat Premium Payment Scheme. This voucher scheme (for eligible home owners) can be exchanged for grant money to install the following technologies:

11.2.1 Air source heat pumps

Heat from the air is absorbed at low temperature into a fluid. This fluid then passes through a compressor where its temperature is increased, and transfers its higher temperature heat to the heating and hot water circuits of the house.
There are two main types of air source heat pump system:
An air-to-water system distributes heat via your wet central heating system. Heat pumps work much more efficiently at a lower temperature than a standard boiler system would. So they are more suitable for underfloor heating systems or larger radiators, which give out heat at lower temperatures over longer periods of time.
An air-to-air system produces warm air which is circulated by fans to heat your home. They are unlikely to provide you with hot water as well.
Installing a typical system costs around £6,000 to £10,000. Running costs will vary depending on a number of factors - including the size of your home, and how well insulated it is, and what room temperatures you are aiming to achieve.
These are the savings you might make every year when replacing an existing heating system in an average three-bedroom semi-detached home with a typical ASHP installation and a good insulation:

Existing system		Air source heat pump performing at 220%	Air source heat pump performing at 300%
Gas	£/year Carbon dioxide/year	-£100 -30kg	£130 800kg
Electric	£/year Carbon dioxide/year	£380 4,440kg	£610 5,270kg
Oil	£/year Carbon dioxide/year	£80 810kg	£310 1,640kg
Solid	£/year Carbon dioxide/year	£100 4,580kg	£330 5,410kg

Table 26 Air source heat pump savings

11.2.2 Biomass-fuelled boilers

Wood-fuelled heating systems, also called biomass systems, burn wood pellets, chips or logs to provide warmth in a single room or to power central heating and hot water boilers.

A **stove** burns logs or pellets to heat a single room - and may be fitted with a back boiler to provide water heating as well.

A **boiler** burns logs, pellets or chips, and is connected to a central heating and hot water system. A wood-fuelled boiler could save you nearly £600 a year compared to electric heating.

A pellet stove will cost around £4,300 including installation. Installing a new log stove will usually cost less than half this, including a new flue or chimney lining.

For boilers, an automatically fed pellet boiler for an average home costs around £11,500 including installation, flue, fuel store and VAT at 5%. Manually fed log boiler systems can be slightly cheaper.

Pellet costs depend mainly on the size and method of delivery. Buying a few bags at a time makes them expensive. If you have room for a large fuel store that will accept several tonnes of pellets at a time, delivered in bulk by tanker, you can keep the cost down to around £190 per tonne in most parts of the UK.

Logs can be cheaper than pellets, but costs depend on the wood suppliers in your local area, as they cost a lot to transport. If you have room to store more than a year’s worth of logs you can save money by buying unseasoned logs and letting them season for a year

This table shows how much you could save by installing pellet central heating in a typical three-bedroom semi-detached house with basic insulation:

Fuel replaced	**Expected saving**	**Expected carbon dioxide saving**
Electricity	£630 a year	7.5 tonnes a year
Oil	£270 a year	3.9 tonnes a year
LPG	£790 a year	3.6 tonnes a year
Coal	£270 a year	7.7 tonnes a year
Gas	£90 a year	3.1 tonnes a year

Table 27 Biomass fuelled boiler savings

11.2.3 Ground source or water source heat pumps

The heat energy stored in the ground, usually at a constant temperature of about 12 ^{o}C, is absorbed into a water/antifreeze solution circulating in pipes buried in the ground or in bore holes.

The system works like a fridge in reverse by using a pump and compressor to enhance this heat and transfer it to an under floor heating system in the building.

Heat pumps do need some power to operate. However, for each unit of electricity they use they can generate up to four units of heat depending on the outside temperature. This is called the Co-efficient of Performance (COP) and models are rated on their COP.

For maximum efficiency the electricity used can be supplemented by some other renewable such as photovoltaics or wind. The system itself is normally operated on an off peak tariff.

Since the system temperature of 35 to 40 ^{o}C is not suitable for the provision of domestic hot water (DHW) it is normally used in conjunction with an immersion heater or a solar thermal collector to achieve 60 ^{o}C for DHW use.

A water source heat pump is similar to a ground source heat pump but the property has to be near a suitable river, stream or lake.

Pipes are submerged under the waterbody where temperatures remain constant at about 7-12 ^{o}C. This heats liquid inside the pipes which passes to a heat pump inside the property.

As with ground source heat pumps, some power is required to operate the pump, but water source heat pumps typically produce three to five times the power they use for heating your home.

Installing a typical system costs around £9,000 to £17,000. Running costs will depend on a number of factors - including the size of your home and how well insulated it is.

Existing system		Ground source heat pump performing at 250%	Ground source heat pump performing at 300%
Gas	£/year Carbon dioxide/year	-£20 400kg	£110 850kg
Electric	£/year Carbon dioxide/year	£510 4,780kg	£650 5,230kg
Oil	£/year Carbon dioxide/year	£160 1,200kg	£290 1,660kg
Solid	£/year Carbon dioxide/year	£160 4,980kg	£290 5,430kg

Table 28 Ground source heat pump savings

11.2.4 Solar thermal hot water

The panels absorb energy from the sun and transfer this energy to heat water. The hot water generated is stored in the special, highly insulated cylinder. This cylinder is designed for use with solar panels and will replace the existing hot water cylinder in retro-fit situations.

The panels can provide up to 60 per cent of a household's domestic hot water needs over a year and can work even in cloudy or overcast conditions. Peak output will occur during summer months when there is more daylight and solar energy available.

For maximum efficiency all solar panels should be mounted on south facing roofs (between SE and SW) at an angle of approximately 30-50 ^{o}C and be clear of shade from trees, chimneys or surrounding buildings.

There are two types of solar thermal panels:

- flat plate
- evacuated tube

The evacuated tube panels can be marginally more efficient, especially in the winter months. They can also be used on shallower sloped roofs by rotating the tubes so that the collectors inside the tubes face the sun. Flat plate panels however can be sized to produce an equivalent output and can be integrated into the roof while the evacuated tube systems are fixed above the roof surface.

Solar water heating systems can achieve savings on your energy bills. Based on the results of the Energy Saving Trust, typical savings from a well-installed and properly used system are £60 per year when replacing gas heating and £85 per year when replacing electric immersion heating; however, savings will vary from user to user.

Typical carbon savings are around 230kgCO_2/year when replacing gas and 500kgCO_2/year when replacing electric immersion heating.

Further information can be found at: http://www.nidirect.gov.uk/index/information-and-services/environment-and-greener-living/energy-wise/energy-saving-grants/renewable-heat-grants/eligibility-for-the-rhpp-scheme.htm

11.3 Future work

Section 10.3 of this report (Conclusions) identified the preferred option for the Draperstown region. Whilst the mix of AD and gasification plant feeding a district heating system has been identified as the best technical option for the area, there are a number of issues that need to be addressed before progression can be made. These are:

- Plant location(s) and district heating pipe layout
- Number and types of properties that each plant will service
- Planning constraints
- Plant manufacturer / technical specifications
- Feedstock source(s) and contracts
- Levels of incentivisation (RHI and ROCs Appendix 4)
- Funding / financing models / mechanisms
- Technology advancement - eg. innovation in renewable technologies, intelligent energy / smart grid, energy storage, biogas upgrade.

11.4 Next Steps

This study has identified that a local renewable energy project could provide between 4-11% contribution to the energy use within the region. In order to effectively realise this contribution, further, more detailed assessment work is required to be undertaken. This work will require additional resources that could (at least in part) be funded / financed through grant support. Our recommendations for the next steps are therefore focused on the mechanisms for identifying the most appropriate support to take the results of this project to practical application stage.

1. Engage with Invest Northern Ireland to investigate the potential to either form, or join an existing Collaborative Network. Collaborative Network funding is available in two phases with an overall aim to support groups of organisations seeking to maximise economic benefit from working together. Phase 1 funding (50% grant from INI) will support the facilitation and some consultancy to undertake a scoping study into a particular sector or sub-sector. Phase 2 then provides further funding to maintain the network for up to three years. A new network could be set up to identify the opportunities from the development of a Draperstown renewable energy solution. It is likely that the network would involve the nine companies within this Innovation Voucher project.

A recent call for expressions of interest in Intelligent Energy Systems (an output from the MATRIX Sustainable Energy Horizon Panel report) under the Collaborative Network umbrella has led to the establishment of a proposal headed up by B9 Energy entitled 6XDSU. Whilst in the early stages of development, the rationale behind the network is to establish a 'demand side unit' demonstrator in each of the six counties of the Province. Discussions with the Managing Director of B9 Energy have established that there is not currently a scheme / community identified in Co. Derry and therefore a real opportunity exists for this group to join the 6XDSU network.

2. Identify other sources of grant funding to support technical development and / or demonstration projects:
   There are a wide range of mechanisms available from Europe and at National level to support research, scoping / feasibility studies and infrastructure development around innovation in sustainable development and energy. The following links provide information on the grant structure at European level and also provided through the Technology Strategy Board (TSB). http://ec.europa.eu/energy/grants/index_en.htm
   https://www.innovateuk.org/energy
   A collaborative network scoping study (outlined above) could include an evaluation of the most appropriate funding mechanisms for the chosen technologies / infrastructure.

3. Community Schemes
   Community energy projects have a focus on:
   - increased local engagement
   - behaviour change
   - local community benefiting collectively from the outcomes

- local leadership
- accountability and/or control
- increased local community ownership

The companies involved in this Innovation Voucher project are ideally placed to maximise the opportunities from development through a Community Energy Scheme that may be part financed by the wider Draperstown community. As a social enterprise, Workspace has wide ranging expertise in operating community projects and indeed Community Funds and could lend expertise to develop a community funding financial model that could provide some capital outlay to the project development fund. Recognising the benefits that a Community Energy Scheme can have on maximising local resource use, creating local jobs, helping to alleviate fuel poverty, making savings through collective purchasing, developing skills & expertise, social cohesion, linking community and commerce and benefitting from financial returns (electricity sales and incentives), the Department of Energy and Climate Change will publish a Community Energy Strategy in Autumn 2013.

Examples of community energy schemes in Northern Ireland include the Drumlin Wind Energy Cooperative. Members of the Cooperative purchase shares in 5 wind turbines that are constructed owned and operated by the Coop with surplus profits (received through energy generation and ROC's) shared amongst the members. £2.69m has been raised by the cooperative to date.

There are a range of support mechanisms for community energy projects. For more information, please see the link below http://www.energysavingtrust.org.uk/Communities/Support-and-guidance

4. Smart Rural

The concept of Smart Cities is attracting considerable interest and significant funding. For some time now the QUESTOR Centre has been in discussions with several companies/organizations about the possibility of establishing a Sustainable Rural Community (Smart Rural) that would adopt many of the technologies being proposed for future Smart Cities (sustainable energy technologies, including energy from sewage treatment, smart metering, sustainable transport etc). The advantage of Smart Rural rather than Smart City is that it would be much easier, initially, to install the infrastructure and to validate the technologies in a rural rather than an urban environment.

As a follow on to this study, the QUESTOR Centre and the Centre for Advanced Sustainable Energy would be prepared to work with the Ballinascreen Parish/Draperstown area to explore the various funding options that could support the development of a sustainable rural community.

12. Appendix 1 Questionnaires

Green Town – Green Space

Workspace and the QUESTOR Centre at Queens University Belfast are working together to promote the development of “Green Town – Green Space”, a scoping study for renewable energy within the Draperstown area. As part of the background survey we would appreciate your support by completing the questions below and returning to School.

Name	
Address	
Are you willing to be contacted for further information if required?	**Yes / No**
Contact telephone number	

Type of home	✓	**Please mark as appropriate**	✓
Detached		**End terrace**	
Semi-detached		**Bungalow**	
Mid terrace		**Flat/ Apartment**	

Number of rooms excluding bath room?	
of which, how many are heated?	
Number of bedrooms	
Number of storeys	
Is the loft insulated?	**Yes / No / Don’t know**
Are the walls insulated?	**Yes / No / Don’t know**

Please provide details about the utility used per year:

Utilities (units)	Total Cost (£/year, quarter, month, week)	Total Units used (units/year, quarter, month, week)
Electricity (kWh)		
Gas (kWh)		
Oil (Litres)		
Solid Fuels (Coal, Turf, wood)		
Vehicle Fuel (Litres)		

The QUESTOR Centre

Green Town – Green Space

PRE-VISIT CHECKLIST

(complete by company and return to j.a.hanna@qub.ac.uk prior to initial visit)

Company and contact details

Company Name:	
Site address: (Including postcode)	
Industry Sector (including SIC code if known):	
Please briefly explain your company's main area of business:	
Please briefly explain your company's key environmental impacts	
Please briefly explain your company's main resource used and waste produced	

No. of employees		Company Turnover	Site Turnover
Name of person responsible for Sustainability		£0 -500k ☐ £3M - £5M ☐ £500k - £1M ☐ £5M+ ☐	£0 -500k ☐ £3M - £5M ☐ £500k - £1M ☐ £5M+ ☐

Section 1 Utilities

Please provide details about the utility use/produced per year:

Utilities (units)	Total Cost (£/year)	Total Units used (units /year)	Utility mainly used for
Electricity (kWh)			
Oil (Litres)			
Vehicle Fuel (Litres)			
Gas (kWh)			
Water (m^3)			

Section 2 Waste Management

Please provide details of your waste origins costs per year in tonnes/litres/skips etc.

Waste (& origin)	Annual Cost (£/year)	Amount Recycled/ Reused	Amount to Landfill
1)			
2)			
3)			
4)			
Hazardous Waste:			

Section 3 Waste Packaging

How much waste packaging does your company dispose of?	Cost (£):	Tonnes:

Section 4 Other Comments

What are your key resource efficiency issues?

During the site visit, we anticipate reviewing the following documents (if appropriate to your company) and would be grateful if they could be made available.

Utilities bills (12 months if possible) – water, energy, other fuel	Invoices – raw materials
Drainage plan	Procedures / Policies / Certificates / Awards (evidence of EMS implementation)
Key Performance Indicators	Continual monitoring data
Meter readings / log books	

For any queries, please call Julie-Anne Hanna on 028 90974675
Or email to j.a.hanna@qub.ac.uk

13. Appendix 2 Domestic Energy Usage Data

	Draperstown				**£/yr**	**£/yr**	**£/yr**	**£/yr**	**£/yr**	**units/yr**	**units/yr**	**units/yr**	**units/yr**	**units/yr**
survey	**home type**	**no. Rooms**	**loft insul**	**walls insul**	**electricity**	**gas**	**oil**	**solid fuel**	**vehicle fuel**	**electricity**	**gas**	**oil**	**solid fuel**	**vehicle fuel**
1	detached bungalow	7	y	y	840		2000	100	2080					
2	detached	8	y	y	600		500	1100						
3	mid terrace	5	n	n	2080		250	1560	1560					
4	bungalow	7	y	n	1040	140	650	100	1300					
5	detached bungalow	6	y	y	1520				2000					
6	mid terrace	6			120							1300		1000
7	detached bungalow	8	y	y	640			1090	2080			1500		
8	detached bungalow	8	y	y	1560			1040	3120					
9	detached	8	y	y	480			1054	1092					
10	detached	12	y	y	600	160	2600	520	2600					
11	detached	8	y	y	900	90	1400		3120					
12	detached bungalow	11	y	y				400		4500	4 cyl	3600		1820
13	bungalow	8	y	y	680		1200	1500	7800					
14	detached bungalow	11	y	y										
15	bungalow	8	y	y	960			1040	2080			1500		
16	detached bungalow	6	y		240		720	360	1040					
17	detached	7	y	n	1040							3600		
18	detached bungalow	6	y	y	1221.26	74.3	1625		2080	6854	75kg	2700		1485
19	detached	9	y	y	744	75	1200		2600					

	bungalow													
20	detached		y	y	1000			250	2600			500		
21	bungalow													
22	detached	8	y	y	1800	120	2000							
23	detached	8	y	y	1040		1500	1500	1000					
24	semi detached	5	y	y	1040		1200		1040					
25	semi detached	10			1000		2000	200	2000					
26	semi detached	6	y	y						5400		1500	625	3640
27	detached	12	y	y	1200		3000	240						
28	bungalow	6	y	n	500	400	1000	700	2500					
29	end terrace	7	y	y	1040		1200		5200					
30	semi detached	6	y	y	560		1200	100	3120					
31	semi detached	8			520							1000		
32	semi detached	9	y	y	1560	260	2600		3120					
33	semi detached	5	y	y	480							1000		
34	semi detached	5	y	y	1002.8		1000		4160					
35	detached bungalow	8	y	y	1200			700	3120			1500		
36	detached	9	y	y	760		1200	864	3360					
37	semi detached	8	y	y	1147.52		1240	1352	2600					
38	detached	7	y	y	480				1560			1200		
39	detached	5	y											
40	semi detached	5			800	200	1200		3000					
41	detached	8	y	y	900		600	200	2000					
42	detached bungalow	9	y	y	936	90	1105		7020					
43	bungalow	12	y	y	1300	80		600	120					
44	semi detached	6	y	y	960	156	900		1200					

45	detached bungalow	7												
46	detached bungalow	7	y	y	31000		5500		1000					
47	detached	11	y	y	796							800		
48	bungalow	6	y	y	1172		1870		2400					
49	detached bungalow	7	y	y	1020		1200		2400					
50	detached	5			600		1000	720	3120					
51	detached	6	n	n										
52	end terrace	7			520	300	1200		1040					
53	detached	2	y	y	980		800							

	Maghera				**£/yr**	**£/yr**	**£/yr**	**£/yr**	**£/yr**	**units/yr**	**units/yr**	**units/yr**	**units/yr**	**units/yr**
survey	**home type**	**no. Rooms**	**loft insul**	**walls insul**	**electricity**	**gas**	**oil**	**solid fuel**	**vehicle fuel**	**electricit y**	**gas**	**oil**	**solid fuel**	**vehicle fuel**
1	detached	8	y	y	1280		1200	20	1200					
2	detached	8	y	y	780	260	1560	312	3120					
3	bungalow	8	y	y	1785.16			1300	1560					
4	detached	5	y	y	1200									
5	detached	6	y	y										

	Cranagh				**£/yr**	**£/yr**	**£/yr**	**£/yr**	**£/yr**	**units/yr**	**units/yr**	**units/yr**	**units/yr**	**units/yr**
survey	**home type**	**no. Rooms**	**loft insul**	**walls insul**	**electricity**	**gas**	**oil**	**solid fuel**	**vehicle fuel**	**electricit y**	**gas**	**oil**	**solid fuel**	**vehicle fuel**
1	detached	9	y	y	320	100			2000			2000		
2	bungalow	9	y	y	900		1350	300	5200					
3	bungalow	7	y	y	560		400	50	200					

	Moneymore				**£/yr**	**£/yr**	**£/yr**	**£/yr**	**£/yr**	**units/yr**	**units/yr**	**units/yr**	**units/yr**	**units/yr**
survey	**home type**	**no. Rooms**	**loft insul**	**walls insul**	**electricity**	**gas**	**oil**	**solid fuel**	**vehicle fuel**	**electricity**	**gas**	**oil**	**solid fuel**	**vehicle fuel**
1	detached bungalow	11	y	y	1320		1200	300	6240					
2	detached	7	y	y	960		1200		1200					
3	bungalow	7	y	y	1272	80	1500	150	2600					
4	bungalow	9	y	y	1378.12	348	1800		12000					
5	detached	8			520			600	2600			6000		
6	bungalow	6	y	y	1000	200	1500	200	100					
7	detached	8	y	y	1436		2000	300	2080					
8	detached	8	y	y	960		1269.6	1352	1300					
9	detached bungalow	8	y	y	676	60	1600	100	3640					

	Desertmartin				**£/yr**	**£/yr**	**£/yr**	**£/yr**	**£/yr**	**units/yr**	**units/yr**	**units/yr**	**units/yr**	**units/yr**
survey	**home type**	**no. Rooms**	**loft insul**	**walls insul**	**electricity**	**gas**	**oil**	**solid fuel**	**vehicle fuel**	**electricity**	**gas**	**oil**	**solid fuel**	**vehicle fuel**
1	bungalow	7	y	y	780		780	260	780					
2	bungalow	7	y	y	2080				3120			2500		
3	detached	14		y	4160		250	50	250					
4	bungalow	5			480				1560			2000		
5	mid terrace	5	y		520			728	2600					
6	bungalow	7	y	y	1000		650	400	4500					
7	semi detached	8	y	y	300	25	300							

	Tobermore				£/yr	£/yr	£/yr	£/yr	£/yr	units/yr	units/yr	units/yr	units/yr	units/yr
survey	**home type**	**no. Rooms**	**loft insul**	**walls insul**	**electricity**	**gas**	**oil**	**solid fuel**	**vehicle fuel**	**electricity**	**gas**	**oil**	**solid fuel**	**vehicle fuel**
1	detached	9	y	y	850	72	870	520	1560					

14. Appendix 3 ROCs and RHI

14.1 Northern Ireland Renewable Obligation Certificates (NIROCS)

The Renewables Obligation is the main support scheme for renewable electricity projects in the UK. It places an obligation on UK suppliers of electricity to source an increasing proportion of their electricity from renewable sources. A Renewables Obligation Certificate (ROC) is a green certificate issued to an accredited generator for eligible renewable electricity generated within the United Kingdom and supplied to customers within the United Kingdom by a licensed electricity supplier. One ROC is issued for each megawatt hour (MWh) of eligible renewable output generated. The Renewables Obligation (Northern Ireland) Order came into effect in April 2005 and the Northern Ireland Renewables Obligation (NIRO) was introduced by the Department for Enterprise, Trade and Investment (DETI).

The NIRO has been subject to regular reviews and the day to day functions of administering the NIRO are performed by Ofgem. Ofgem, based in London, is responsible for the process of accrediting renewable energy installations and issuing Northern Ireland Renewable Obligation Certificates (NIROCs) to generators in Northern Ireland. Power NI is an Ofgem Agent for generators up to 50kW so we can help smaller generators to get accredited with Ofgem and to manage the ongoing NIROC administration on their behalf. From 1 April 2010, DETI introduced an increase in NIROC banding levels for some renewable energy technologies. Existing generating stations will remain on double NIROCs, while stations accredited on or after 1 April 2010 may be able to avail of the higher ROC bandings and relevant payments as shown in the Table 29:

The current ROC unit price is:

Tariff from 1 October 2012 – 30 September 2013

1 ROC for generators up to 50kW 4.41p/kWh

		Banding Level	Agent customers	Non-agent customers (up to 50kW)
Existing Microgeneration		2 ROCs	8.82p/kWh	£88.20/MWh
Wind	Up to 250kW	4 ROCs	17.64p/kWh (up to 50kW)	£176.40/MWh
	250kW – 5MW	1 ROC	n/a	£44.10
Photovoltaic (PV)	Up to 50kW	4 ROCs	17.64p/kWh	£176.40/MWh
	50kW – 5MW	2 ROCs	n/a	£88.20/MWh
Hydro	Up to 20kW	4 ROCs	17.64p/kWh	£176.40/MWh
	20kW – 250kW	3 ROCs	13.23p/kWh (up to 50kW)	£132.30/MWh
	250kW – 1MW	2 ROCs	n/a	£88.20/MWh
	1MW – 5MW	1 ROC	n/a	£44.10/MWh
AD	Up to 50kW	4 ROCs	17.64p/kWh	£176.40/MWh
	50kW – 500kW	4 ROCs	n/a	£176.40/MWh
	500kW – 5MW	3 ROCs	n/a	£132.30/MWh
Biomass	Up to 50kW	2 ROCs	8.82p/kWh	£88.20/MWh
	50kW – 5MW	1.5 ROCs	n/a	£66.15/MWh

Table 29 ROC Banding

14.2 The Northern Ireland Renewable Heat Incentive

The Northern Ireland Renewable Heat Incentive (RHI) is a DETI scheme that provides financial support to non-domestic renewable heat generators and producers of biomethane.

14.3 Scheme Rationale

The primary objective for the Northern Ireland RHI is to increase the uptake of renewable heat to 10% by 2020 (baseline position of 1.7% in 2010). The 10% target for renewable heat equates to 1.6TWh (or an additional 1.3 TWh when considering existing levels). This target was included in the Strategic Energy Framework and an interim target of 4% renewable heat by 2015 has been included in the Programme for Government.

In addition to achieving the set target, it is expected that the RHI will have a number of other wider benefits in terms of fuel security, lower emissions and ‘green jobs’.

Renewable heat technologies are currently unable to compete with existing fossil fuel alternatives given the often higher capital costs and also the lack of understanding and awareness amongst consumers of what are often seen as innovative technologies.

Without the RHI in place Northern Ireland will not achieve either the targets set for renewable heat by the Northern Ireland Executive in the SEF or be able to contribute to the UK target set under the Renewable Energy Directive.

14.4 Tariffs Design

The RHI aims to compensate investors for the additional costs of renewable heat compared to traditional fossil fuel systems. For each technology, we have taken into account all the various types of costs involved (including capital, financing, barrier, fuel and operating) to produce a pence per kWh cost figure – this is known as a levelised cost methodology.

The RHI tariff setting methodology also includes the provision of a rate of return in order to stimulate interest in a developing unknown marketplace and to provide compensation for financing costs of making the necessary investment in capital projects. In most instances a rate of 12% has been set. Solar thermal receives a lower rate of return as it is a well-known technology, it's relatively easy to install and it will not displace the same level of fossil fuel as the other technologises. In addition solar thermal heat is, at present, more costly per unit of energy than other technologies.

14.5 NIROCs in relation to biomass installations over 1MW in size?

Biomass installations over 1MW in size will not receive a tariff under the current banding proposals. The reason for this is that, analysis has shown that it should be cost effective for these sites to switch to renewable heat by 2020 and therefore an additional incentive is not required. Indeed, when calculating a tariff for these technologies, using the same methodology as for the others, the calculated value is negative i.e. no tariff is required. DETI is however willing to examine any alternative evidence as part of the second phase of RHI.

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